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TREE PRESERVATION BULLETIN NO. 9 JANUARY 1940

TRANSPLANTING TREES AND OTHER WOODY PLANTS

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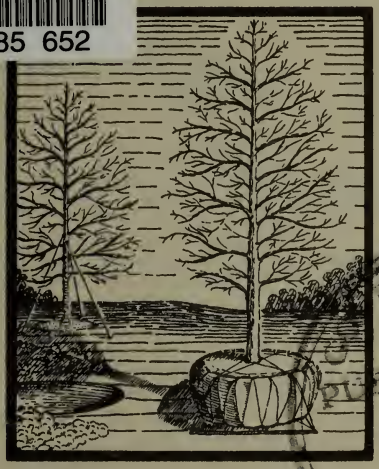

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CONSERVATION BULLETIN NO. 5

UNITED STATES
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TREE PRESERVATION BULLETIN NO. 9

TRANSPLANTING TREES AND OTHER WOODY PLANTS

BY
A. ROBERT THOMPSON, FORESTER

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TRANSPLANTING TREES AND OTHER WOODY PLANTS

by A. Robert Thompson, Forester

Part I of Chapter III, Standard Practices

Tree Preservation Bulletin Series

INTRODUCTION

The moving or transplanting of trees and shrubs is an activity probably as old as mankind. Basically the process of moving growing plants from one place to another is little changed from early times, but our increased understanding of the processes of nature through recent research and investigations in the broad fields of horticulture, arboriculture, and forestry and the development of improved machinery and equipment have brought about many improvements in the technique of moving trees and shrubs. Today the moving of trees 12 to 18 inches in diameter is a matter of routine, and trees several times as large frequently are transplanted with success. The cost of such operations is relatively high and seldom in national park work is it justifiable except under special conditions.

The transplanting of small- to medium-sized trees and shrubs, however, is a constantly recurring activity in areas under Service jurisdiction, and it is to aid the planners and supervisors of such work that this bulletin is issued. Because of the varying conditions of climate, soil, temperature, species, etc., encountered in national park areas it is impossible to lay down rigid rules for transplanting, but the principles involved are the same in Maine as they are in Texas, and it is hoped that a codification and explanation of some of these principles and descriptions of certain techniques will prove to be adaptable and of value under many of the various conditions encountered.

Acknowledgment

In the preparation of this bulletin the author has drawn freely from the sources listed in the bibliography and in addition is greatly indebted to many scientists and practicing arborists for critical advice and suggestions. Special thanks are due Dr. L. C. Chadwick of Ohio State University, Dr. F. L. Mulford of the U.S. Department of Agriculture, Charles F. Irish of Cleveland, Ohio, E. W. Higgins of Arlington, Mass., R. M. Weakley of Warren, Pa., H. L. Jacobs of Kent, Ohio, F. W. Roewekamp of the Los Angeles Park Department, Edward H. Scanlon of Santa Monica, Calif., H. Dana Bowers of the California Division of Highways, and various colleagues in the National Park Service for their complete review of the manuscript or helpful advice on special phases of transplanting.

CHOICE OF PLANT MATERIALS

The planning and design of any program involving a change in the appearance of an area is, in the National Park Service, essentially the province of the architect and landscape architect. The desirability, however, of having the plantsman* collaborate with the designer in evolving planting plans cannot be seriously questioned. This is particularly true in the selection of species for a specific purpose or landscape effect. The designer is primarily concerned with the rhythm, balance, and harmony of a completed landscape composition, but he needs the practical advice and experience of the plantsman in selecting the plant materials so that only healthy, vigorous, well-formed specimens are chosen. It costs no more to move a healthy shrub or tree than it does a crippled one and only through the selection of the former can a successful planting be had or permanence be secured. Occasionally, it is true, one man combines the abilities of both designer and plantsman, and this is, of course, highly desirable, but, more often perhaps, the abilities of one are supplemented, not duplicated, in the other.

Aesthetic Considerations

It is not within the scope of this short bulletin and it would be obviously presumptuous on the part of the author to enter into a discussion of the vast field of landscape architecture, but since many plantsmen who may use this bulletin do not have the benefit of landscape advice a brief mention of some of the major aesthetic features which the landscape architect must consider in the selection of plant materials may be in order.

Purpose.—First consideration must, of course, be given to the purpose of the planting. It may be to frame a vista or soften building lines, cover a road slope, serve as a windbreak or background, provide shade in developed areas, recover a barren area, protect slopes from erosion, serve as a game or bird refuge, or provide a foundation planting around a building or monument but whatever the purpose certain basic principles of form, size, color, and texture should be considered in the selection of final plant materials in order that they may blend properly into the completed composition.

Form.—Form must be considered both in the mass and in the individual. It may be that the design requires a blending of irregular individual shapes so that no individual or group of individuals is predominant, but on the other hand it is frequently desirable to emphasize certain aspects of the design by means of plant forms. Both shrubs and trees are available in such varied shapes or habits that the designer may use many contrasts in his composition, varying his plant materials from

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* Plantsman. The term is used herein to denote a person qualified by adequate training and practical field experience to direct all phases of a transplanting operation including care before and after the actual transplanting.

spreading or globe-shaped specimens to those which are columnar, vase-shaped, fastigiate, or conical in habit.

Color and Texture.—The designer has many opportunities to use color and texture contrasts for points of interest in his composition. The varying tones and shades found in foliage, stems, flowers, and fruit, enable him to present, if he desires, a picture of ever-changing aspect and one which is interesting at any season of the year. The many variations of foliage, bark, and structure are also used to advantage to provide interesting contrasts and blending of texture.

Size.—Of paramount importance to the designer is the matter of size of materials. He must so conceive his design that the ultimate as well as the present picture will be a pleasing composition. Plants grow at widely varying rates and many designs have been ruined by failure to take this factor into consideration. Unless there is a real necessity for the creation of an immediate effect by using very large stock, it is usually cheaper and easier to plant small or medium sizes. This is especially true in public work where long range planning is, or should be, a major objective.

The very important factor of longevity is closely related to the rate of growth. In most cases rapidly growing plants are weaker and shorter lived than those which reach maturity more slowly.

Practical Considerations

Since trees and shrubs are among the more permanent elements of a landscape, both the designer and the plantsman should be thoroughly familiar with not only their ornamental properties, their rates and habits of growth, but with their requirements in regard to soil, climate, and other environmental factors. Trees and shrubs are living organisms and as such thrive only under conditions favorable to their individual requirements. While some species may be found growing or may be adapted to a wide range of environmental conditions, each does best where the soil and climate are most favorable to its specific needs. This point should be kept constantly in the mind of the designer when he is considering the selection of his plant materials. Mulford, in his excellent bulletin, "Trees for Roadside Planting", (39) divides the United States into 32 regions and gives lists of trees suitable to each. One not familiar with the species suitable for any particular section of the country would do well to consult this publication and others of a similar nature.

Native vs. Exotic Materials.—One way in which the designer may be assured that his choice is reasonably good is in the selection of native materials found growing or known to grow near the planting site and in the same general environment. The use of native materials to the almost complete exclusion of exotics is, of course, a basic Service policy and one which is

highly justified not only from the viewpoint of keeping the parks in their native state as specified in the organic act which provided for the National Park Service but for reasons of plant hardiness, ease and relative cheapness of procurement, harmony of design, and economy of maintenance. The policy of excluding exotics does not apply so exclusively to such urban areas as National Capital Parks or national cemeteries where suitable exotic species frequently are highly desirable.

Climate.—Among the most important practical factors which must be considered before selecting plant materials is the matter of a comparable climate between the growing site and the planting site. Included in such considerations are the extremes of temperature and the time of occurrence as well as the duration of both high and low temperatures. Most species are limited in the degree of heat or cold which they can withstand without injury and this limit may even vary within the species and be dependent upon the temperature variations where the stock is grown. In this connection it should be noted that species which are occasionally tender in a certain locality frequently are more hardy if propagated from seed or vegetative propagating material secured from plants native or being grown in the northern regions even though propagation for a year or two may have been farther south.

The amount of annual precipitation and the time of occurrence are of vital concern to the plantsman since authorities are agreed that the availability of an adequate moisture supply, seasonably distributed for the species, is one of the most important limiting factors of growth. In some regions precipitation is well distributed throughout the year but in others it may be limited to a relatively brief period or periods. Such conditions are reflected in the vegetative types found growing naturally in the region and should, of course, be carefully considered in the choice of materials and the season for transplanting.

Exposure and Elevation.—When selecting plant materials for a particular location any considerable changes in exposure and elevation should be avoided. Trees and shrubs which have been growing naturally on a site which is sheltered from heavy winds and strong sunlight are naturally averse to being moved out in the open where they may be exposed to strong winds and more direct rays of the sun. The reverse of this is equally true. Species, and to a lesser degree individuals also, which occur naturally in the open usually do not thrive in heavily shaded locations where they do not get their accustomed ration of sunlight. Relatively young plants are more adaptable to environmental change than older ones and well grown nursery stock usually is less affected by change than wildings but almost any tree or shrub will reveal its lack of tolerance to drastic changes by poor growth, decreased resistance to disease and insect attack, stunted habit, or perhaps early or premature death.

Elevation, with its associated factors, should be given

consideration by the designer and plantsman since trees and shrubs do not take kindly to any great change in altitude. Even slight changes frequently are hazardous. It is obvious, for instance, that a lowland tree accustomed to rich moist soil would be under a severe handicap if transplanted to a high exposed dry site, but it is also true that a species which has adapted itself to the rigors of a high rocky dry site might have considerable difficulty in thriving under lowland conditions. In the case of nursery grown stock much the same condition prevails. As a rule, the best stock is raised from seed or cuttings taken from trees most characteristic of the type which are growing under conditions of elevation, climate, and exposure comparable with the nursery and planting sites.

Soil and Terrain.—There are many soil factors which the plantsman should consider in determining where to select his stock for transplanting to a given site. He should study the depth of soil to hardpan or the water table, the size and arrangement of soil particles; the degree of soil acidity; the amount and relationship of organic matter; the degree of soil aeration; and available moisture. He should also consider the general terrain and slope of the section and the specific sites as different rooting habits are found on trees when growing in soils of different types.

It is of great importance whether either or both of the soils are heavy clay, sandy loam, loose gravelly glacial till, or some other combination of soil particles. Digging, hauling, and planting techniques will vary considerably with different types of soil and should be carefully planned prior to any actual field work since it may be desirable to change the character of the soil at the planting site somewhat before transplanted material can be expected to thrive, as, for example, the provision of drainage; the addition of sand and peat moss to a heavy clay soil to lighten it; or the incorporation of organic matter with sandy soil to increase its moisture-retaining and nutritive qualities. It is seldom practical to change the character of a soil on a large scale due to the large quantities involved. A better practice is to select species which will thrive in the existing soil.

It is rarely practical for the plantsman to make a complete chemical analysis of the soil, but he should know the pH or relative acidity of the soil which the plant prefers to be sure that the transplanted material will be tolerant to the degree of acidity present at the planting site. If the required soil acidity or alkalinity is not known it may be tested where the plants are thriving. Some species of the broad-leaved evergreens, rhododendron, laurel, etc., will thrive only in quite acid soils while other plants require slightly acid, neutral, or alkaline soils.

The amount of organic matter present in the soil is undoubtedly of great importance, as such material not only makes the soil more porous and friable but the carbon dioxide formed

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makes many of the plant nutrients more readily available. In addition the organic matter serves as a culture medium for various soil organisms which assist in breaking down the organic matter, thus releasing various other nutrient materials and making the soil more fertile and stimulating root activity. It should be noted, however, that the quantity of organic materials in poorly drained soils may reach a point of toxicity.

The presence of adequate and sustained soil moisture and proper aeration are two of the most important aids to healthy plant growth and the absence of sufficient moisture or an overabundance is soon revealed by decreased growth. These factors are of especial interest to the plantsman since he must make provision for periodic watering if soil moisture is deficient, special drainage for excessive soil moisture, and some type of cultivation if aeration is inadequate as is found frequently in heavy clay soils.

All of the foregoing factors are directly related to the terrain or lay of the land. Other things being equal, vegetative growth tends to be best in draws or swales because of generally better soil, less exposure to drying winds and extremes of heat and cold, and more abundant moisture while growth tends to be poorer on steep slopes and hilltops for converse reasons. Convenience in digging and hauling is also somewhat dependent upon terrain and the experienced plantsman will take all of these matters into consideration when selecting his source of collected plant materials.

Season for Transplanting.—There is a variance of opinion regarding the best time of year for transplanting. Some authorities recommend fall, some winter, some spring, and still others point out that plants may be successfully moved at any season of the year, but with less trouble at some seasons than at others. A great deal depends on geographical location, climate, and the species to be transplanted. What might be the best season in one part of the country is not so good in another and what might be best one year may not be as favorable the next. Much depends on temperatures, rainfall, and soil, and it is well before initiating a planting program to understand the local conditions which favor success, as well as the individual requirements of the species being moved.

It is a matter of simple observation that trees and shrubs frequently are moved every month in the year in many parts of the country. It is true, however, that plants moved during periods of rapid growth will suffer more unless especial care is taken. In regions of mild winters planting usually starts early in the fall and continues through the spring months whereas in regions of severe winters transplanting—particularly of evergreens—should be avoided during the coldest months.

All plants go through a period of dormancy or cessation of growth though the period is most pronounced in regions having well defined seasons of heat and cold. The vital processes

never quite cease altogether, however, since roots continue to grow during all or a part of the cold season and there is always more or less loss of moisture through transpiration. The periods of repose for roots and shoots do not necessarily coincide and the periodicity of growth varies between conifers and deciduous plants. Studies have shown that root growth of conifers may be suspended during very cold weather and slow down considerably during midsummer whereas in deciduous trees root growth does not appear to cease entirely even in midwinter. During periods of drought, however, root growth in any species may cease and then pick up again when moisture becomes available. As a general rule root growth begins its seasonal rapid development a few days or several weeks prior to bud growth.(55)

In general, plants should be dormant before planting begins. While, as noted previously, the dormant period varies with species and localities, in most regions evergreens are most successfully moved earlier in the fall and later in the spring than deciduous plants. Chadwick (14) points out that if fall rains are early and it is possible to move evergreens so that their roots are well established before the ground freezes, fall will prove an excellent time for transplanting. He cautions against transplanting to a cold soil, however, and points out that many evergreen failures have resulted when planting is too late in the fall or too early in the spring for the plant to start root activity at once. In locations which are exposed to high winds, spring planting of evergreens generally is preferable to fall planting.

For successful transplanting there must be an abundance of soil moisture available but not an excess. Mulford (38) recommends fall as the more desirable time of the year for planting in regions having very hot dry summers because of the longer time afforded for roots to form before hot dry weather comes and points out that in the colder portions of the great plains region only spring transplanting should be attempted unless it is possible to water the plants thoroughly in the fall, provide them with a mulch to prevent the ground from freezing as deeply as the roots extend, and to protect the tops by providing a windbreak, and boxing or wrapping to prevent drying out by winter winds. Fall transplanting is recommended in the warmer parts of the great plains region if an abundance of water can be supplied. As a general rule, the longer the planting is done before hot weather sets in the better, provided there is adequate soil moisture available. If the soil is excessively wet, however, it is well to delay planting until more normal conditions obtain.

When plants, especially evergreens, are moved in the fall it is especially desirable to see that they go through the winter with plenty of soil moisture so that early winds will not dry them out before the roots are functioning and normal circulation and translocation start. Watering during winter thaws is beneficial if the soil is dry—especially with evergreens—and the use of windbreaks is frequently justified.

FIG. I
TYPES OF ROOT SYSTEMS

Some species of plants, while readily moved in the spring of the year, do not readily re-establish themselves when moved in the fall or winter. Included in the group which are safely moved only in the spring are the magnolias, yellow poplar, yellowwood, sassafras, and others which have a similar fleshy type of root structure.

Adaptability to Moving.—Plants, especially trees, vary widely in their adaptability to moving. As a general rule, species with tight, compact, fibrous root systems will adjust themselves more easily to the shock of transplanting than those with sparse elongated root systems or those with major tap roots. While plants of the same species tend to have the same general type of root system, frequently there will be a surprisingly wide variation within the species depending upon the type and depth of topsoil, type of subsoil, presence and depth of hardpan, depth and constancy of water table, presence or absence of a natural mulch, and other environmental factors. Before selecting plants for moving, all of these contributing factors should be taken into consideration.

In a recent publication, Jacobs (28) has this to say about the relative difficulty of moving trees of various species. "Because evergreens are evergreen and have to be moved in leaf they must be considered in the difficult class. In this group are all the conifers, including larches and bald cypress. These last two, while deciduous, are generally shallow-rooted and are not among the easiest to transplant. All broad-leaved evergreens also require special care because the leaves demand water continuously regardless of the time of year when they are transplanted. Among these are rhododendrons, mountain laurel, evergreen azaleas, evergreen hollies, daphnes, firethorns, andromedas, southern magnolia and other genera and species common to both northern and southern landscapes."

A recent survey conducted by Ohio State University (13) resulted in the listing of several tree species as to ease in moving. A combination of this list, which applies principally to large sizes, together with a similar one compiled by Jacobs (28) and added to and modified by various collaborators is given on page 10. Names are given according to Sudworth (51) when listed, otherwise according to Standardized Plant Names (43). While this list admittedly is incomplete and perhaps open to differences of opinion, it should serve as a guide to indicate that special precautions should be taken in moving trees--especially large ones--of the type listed as relatively difficult. It should be noted that trees with large fleshy roots--the magnolias and yellow poplar for example--transplant more readily in the spring than in the fall.

Damage Possibilities.--In spite of the care that is taken in transplanting, the work frequently is nullified or ruined by failure of the plantsman to take into consideration the possibility of future damage caused by animals, insects, diseases, human beings, wind, sleet, atmospheric gases, soot, and other destructive influences. Many of these may be ameliorated or prevented if proper precautions are carried out, but a careful choice of species which are resistant to or not affected by these influences will minimize future trouble and, of course, care should be used in selecting vigorous specimens as such are less susceptible to attack as a general rule.

Damage caused by the gnawing of rodents may be prevented by placing guards of wire or building paper around the trunks of tender-barked trees. Some success has also been attained through the use of sulfurized oil painted on the trunks to repel rabbits and mice. The nesting of rodents around newly planted or mulched trees may be prevented by delaying the application of the mulch until after the ground freezes.

The control of browsing of various forms of wildlife is difficult since little success has been attained through the use of repellent chemicals, but the erection of barriers, and the selection of species less attractive to animals has been somewhat successful.

Since it is easier to prevent insect and disease attacks than it is to control them, plants selected for transplanting should be free from such pests. The plantsman should be thoroughly familiar with the various diseases and insects found in his area before he selects his stock. He should know what epidemic diseases and insects are present in the general vicinity and which ones are likely to move in and give trouble in the future. He should be especially familiar with those parasites which depend on alternate hosts for the completion of their life cycle so that he will not make the mistake of placing such hosts in dangerous proximity.

Human beings are difficult to control, but suitable guards and barriers will often prevent damage caused by the careless

List of trees indicating relative ease in transplanting
compiled by
Ohio State University (13)

Scientific Name	Common Name	Transplanting Data***
Acer sp.	Maple	E
Aesculus sp.	Buckeye, Horsechestnut	E
Ailanthus altissima	Ailanthus	E
Amelanchier canadensis	Serviceberry	H
Amygdalus persica	Peach	H
Betula sp.	Birch	H
Carpinus caroliniana	Blue Beech	H
Catalpa sp.	Catalpa	E
Celtis occidentalis	Hackberry	E
Cercis canadensis	Redbud	H
Chionanthus virginica	Fringetree	H
Cladrastis lutea	Yellowwood	H
Cornus sp.	Dogwood	H
Crataegus sp.	Hawthorn	E
Diospyros virginiana	Persimmon	H
Elaeagnus angustifolia	Russian-Olive	H
Fagus grandifolia	Beech	H
Fraxinus sp.	Ash	E
Ginkgo biloba	Ginkgo	E
Gleditsia tricanthos	Honey Locust	E
Gymnocladus dioicus	Coffee tree	H
Hicoria pecan	Pecan	H
Ilex opaca	Holly (with foliage)	H
Juglans sp.	Walnut	H
Laburnum sp.	Laburnum	H
Liquidambar styraciflua	Red Gum (light soils)	E
Liquidambar sytraciflua	Red Gum (heavy soils)	H
Liriodendron tulipifera	Yellow Poplar	H
Magnolia sp.	Magnolia	H
Malus sp.	Apple	E
Nyssa sylvatica	Black Gum	H
Ostrya virginiana	Hop-hornbeam	H
Oxydendrum arboreum	Sourwood	H
Paulownia tomentosa	Paulownia	E
Pinaceae (all)	Conifers (all)	H
Platanus sp.	Sycamore	E
Populus sp.	Poplar	E
Prunus sp.	Cherry	H
Pyrus communis	Pear	E
Quercus palustris	Pin Oak	E
Quercus (most sp.)	Oak	H
Salix sp.	Willow	E
Sassafras variifolium	Sassafras	H
Sorbus americana	Mountain Ash	E
Toxylon pomiferum	Osage-orange	E
Ulmus sp.	Elm	E

*** E-Relatively easy to move
H-Relatively difficult to move and/or slow to recover

or malicious.

The amount of wind which plants will withstand without injury varies considerably, and this factor should be carefully considered before any particular species or individuals are selected. Adequate bracing and pruning of transplanted stock will assist in preventing mechanical damage by wind and sleet and the erection of screens or guards and frequent syringing of the crowns will prevent or mitigate damage caused by severe drying winds.

Selection of species resistant to unfavorable atmospheric gases and soot will go a long way in preventing damage from this cause. Once a nonresistant species is planted, however, the damage often may be ameliorated by washing the foliage frequently with soap and water.

Root Pruning

When opportunity permits it is desirable, under some conditions, to prepare certain types of wilding trees and shrubs for transplanting by root-pruning them a year or two ahead of the actual moving. (Fig. 2) Such a practice encourages the development of fibrous roots close to a sparsely rooted plant and minimizes shock and root loss at the time of moving. Plants which grow in the open and have a normal, vigorous root system with an ample supply of well distributed fibrous roots rarely require this attention but root-pruning frequently is beneficial for plants which have a tendency toward developing a few long roots with the majority of feeding roots at the ends. This type of plant is very difficult to move without such preliminary attention, as it is almost impossible for the plantsman to retain enough roots on the plant to enable it to recover from the root loss.

Although many experienced arboriculturists believe firmly in the desirability of root-pruning--especially of those species which are relatively difficult to transplant--others feel that perhaps more is gained by omitting the root-pruning of trees to be moved with a ball but compensating for the omission by more careful digging; taking a larger ball; more drastic pruning; and more careful maintenance after the tree is planted. They point out that a root-pruned tree requires essentially the same maintenance as a transplanted tree and that the cost of such maintenance is prohibitive when the root-pruned trees are not readily accessible.

Both viewpoints doubtless are justified by the conditions under which they were formed since soils and other environmental factors vary so much in the various parts of the country that few general rules are always applicable. What might be considered justifiable expense under certain circumstances might be uneconomical as a general policy. Extensive experience under similar conditions should determine the desirability of root-pruning.

If root-pruning is deemed advisable under local conditions, it is best done at least one full growing season in advance of the moving operation. Early spring often is the best time for root-pruning generally as roots make their best growth during this season, but some authorities prefer to root-prune in the early fall as seasonal rains start. Local conditions should be the determining factor in deciding when to root-prune. On small trees and shrubs root-pruning may be accomplished by severing the lateral roots with a sharp spade in a circle around the stem. The distance this circle is made from the stem will vary, of course, with the size of the plant, the rooting habits of the species, the type of soil, and the ultimate size of the earth ball to be moved with the plant. Judgment needs to be exercised in each case but, in general, if the circle is cut so that 1 inch of stem diameter equals 10 inches of circle diameter the results usually will be satisfactory.

On larger plants and trees it is necessary to dig a trench all around the tree. The same rule of thumb mentioned above is quite generally satisfactory for locating the inner wall of the trench, which should extend to the depth of the root system. As roots are encountered they should be severed cleanly with root-pruners or some other sharp instrument, and it is a desirable practice to paint cut ends with a good pruning compound. After the trench is dug it should be backfilled with good topsoil and, if available, a mixture of granulated peat moss, well rotted manure or compost is helpful. Fertilization by the crowbar method within the ball is highly desirable to induce added fibrous root growth in this area since it is doubtful if many of the fine new roots outside the ball will survive the actual moving. If rain is plentiful artificial watering may be unnecessary, but during dry weather the ball and trench should be well watered at intervals of a week to assure adequate soil moisture for maximum root growth.

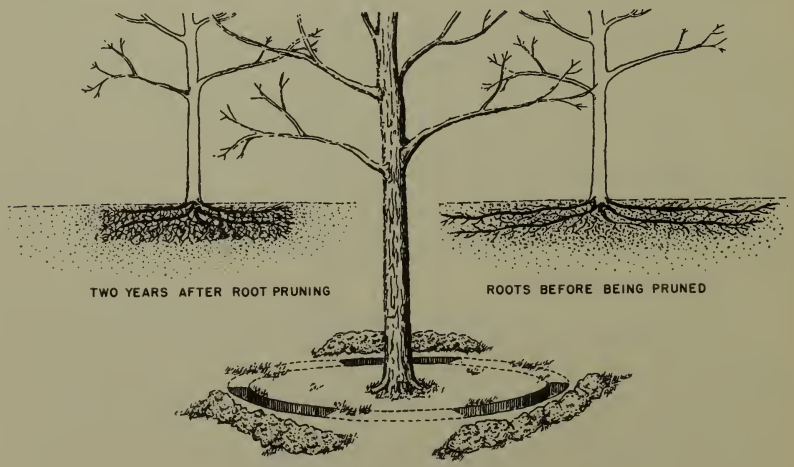

FIG. 2
ROOT PRUNING - TWO YEAR SYSTEM

If the transplanting operation can be anticipated far enough in advance it is considered good practice by some authorities to extend the root-pruning operation over a period of two years, pruning half the root system the first year, half the second, and doing the transplanting a year later. Mulford (38) recommends that this type of root-pruning be accomplished by laying off the proposed trench into six equal segments and digging alternate segments in successive years and backfilling as mentioned previously.

In order to minimize the shock to the tree and compensate for the lost roots it is desirable to prune the crown at the same time the roots are pruned. The degree of top pruning should correspond to the amount of roots cut.

Nursery Grown versus Wilding Stock

Many of the factors which prohibit or decrease the possibilities for success in moving wildings are overcome by intelligent care and training in a well managed nursery. Due to repeated transplanting, root-pruning, and top pruning, nursery grown stock will have a stronger, more compact root system and a better crown than wilding stock and, the chances are, will be grown in a type of soil better adapted for handling.

It should be noted that the advantages of nursery grown plants diminish with the distance of the nursery from the planting site since stock grown nearby has less chance of drying out before planting and has the advantage of having been grown under more nearly similar climatic conditions.

It is realized that limited funds very often preclude the purchase of nursery grown plants for public work where there is sometimes an abundance of labor but inadequate money for purchasing materials, but where these factors are not insurmountable the increased survival of nursery grown stock very often makes it more economical to purchase rather than collect stock from the field, no matter how easily and cheaply obtained such stock may appear to be.

It is frequently good judgment, especially on large operations, to line-out wilding stock in transplant beds for a year or two prior to final planting when opportunity permits. If the beds are suitably located, such a practice allows more thorough maintenance and cultivation than would be practical in ordinary field operations, thus encouraging the development of stock which has a better chance for survival when planted in its ultimate location. This practice is especially valuable in the case of evergreens.

Choice of Individual Plants

With the foregoing general aesthetic and practical considerations clearly in mind the plantsman is faced with the problem of selecting the individual trees and shrubs to carry

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out the planting scheme. If nursery stock is to be used the choice of individual specimens is frequently left to the nurseryman but if wildings are to be transplanted the plantsman must depend on his own judgment to select vigorous, well-rooted stock that is accessible and relatively easy to dig and that is structurally sound and free from insects and disease. Some of the factors having a bearing on the selection of individual plants are brought out in the discussion below.

Location.—The economy of the operation, particularly if it is an extensive one, is largely dependent upon the location of the material. Distance is not so important in these days of truck operation, but the ability of the driver to get close to the digging and planting sites, particularly when trees are being handled, is an important factor. This will depend on the proximity to roads, the condition of the ground, whether plant materials are growing in the open or in the forest, the slope of the ground, elevation, etc. It is impossible to lay down any rules on this point, but the problem should be carefully studied before plants are selected as it may be found that it is better to bring plants from quite a distance over good roads rather than attempt to bring them out over soft ground even though growing closer to the planting site.

Exposure.—Plants growing well separated in a fairly open area are usually better adapted to transplanting than those found in thickets or in the forest. Usually they are thriftier, better shaped, and have an easier type of root system to handle than those growing in competition with other plants. In addition plants grown in the open are less subject to sunscald and wind injury than stock grown in more sheltered locations since they have developed a resistance to such injuries by gradual exposure and immunization.

Digging Conditions.—Most small deciduous plants ordinarily are moved successfully bare-rooted but evergreens and larger deciduous trees should be moved with their root systems intact so far as possible and with an undisturbed ball of earth around the roots. Good digging conditions for these two types of moving will vary. In order to fork out successfully the roots of deciduous plants the soil should be of a rather sandy loam type, but if a ball of earth is to be retained the soil should be somewhat heavier, preferably of a clay loam type and relatively free from large stones. For good digging the soil should not be so wet that it will puddle but on the other hand neither should it be so dried out that it will crumble. Delaying the operation until the soil is in suitable condition for digging frequently is good judgment. In general it is easier to establish trees transplanted from a heavy soil to a site having a somewhat lighter soil than from a light or sandy soil to a heavy clay soil.

Root System.—A plant selected for moving should have a compact but well branched root system with an ample supply of fibrous roots. So far as the plant itself is concerned a good

root system is probably the most important single factor for success in transplanting since upon this system the plant must depend entirely for mechanical support and the water and nutrient materials needed for life and growth.

The root system will be influenced in its development by the type of soil in which it is growing, the depth of the topsoil, the character of the subsoil, available moisture, and competition with other plants, as well as by the inherent growth tendencies of the species. In general, it is safer to select plants for moving which have a relatively shallow type of root system for the species rather than those which are deeply rooted.

The origin of the stock is also important. Plants growing from seedlings are easier to handle than sprout growth of any kind, and stump sprouts always should be avoided.

Vigor.—The vigor of a plant may be indicated by several symptoms; the length of annual twig growth, the size of buds, the rate of callusing of wounds, and the color in bark fissures. (Fig. 3) The normal annual twig growth varies, of course, between different species, but an average length of 4 to 8 inches between terminal bud scars will indicate reasonably good vigor if this is not below the average indicated by the growth of previous seasons. Buds should be plump and well filled for the species since abnormally thin and nonturgid buds indicate retarded development. The color of bark fissures is a good indicator of vigor. To denote a satisfactory growth rate the color in the fissures should be considerably lighter than on the bark surface, thus indicating satisfactory cambium activity. Any small wounds on the tree or shrub should be examined. If these

AMPLE TWIG LENGTH RAPID CALLUS AND CAMBIUM GROWTH FIRM, TURGID BUDS

FIG. 3
INDICATIONS OF A VIGOROUS TREE OR SHRUB

are healing well with a good roll of callus forming over the wounds good circulation is indicated. The color and size of leaves is another good indicator of plant vigor, but unfortunately foliage is absent during the normal transplanting season for deciduous stock. If preliminary observations can be made prior to the planting season this symptom will be of value and any variation less than normal should be viewed with suspicion.

Symptoms of poor vigor may indicate lack of available food and water in the soil, a poor season for growing, some form of interference with the circulatory system, or crowded growing conditions, but whatever the cause of retarded growth it is well to avoid choosing such specimens for transplanting since the results probably would be disappointing.

Structure and Habit.--The plant selected for transplanting should have a structure above ground which is suitable for the purpose intended. Shrubs usually should be full bushy specimens, but tall leggy ones frequently are useful for background planting. Trees should be shapely and have single uninjured leaders, as a rule, since multi-trunked specimens--especially those with low crotches--are hard to handle and are only infrequently satisfactory. Any crotches in the tree should be sound and unsplit and trees with decayed spots, old frost cracks, lightning scars, visible sporophores or cankers should be avoided. Specimen evergreens should be well rounded, evenly branched and bushy to the ground.

Insects and Disease.--Plants should be looked over carefully for any sign of insect or disease attack. Careful examination of the trunks and stems for holes, slime spots, sunken areas, ridges, or sawdust-like frass will be necessary to avoid the possibility of borer-ridden stock. Twigs and branches should be inspected for possible scale insects, twig disease cankers, and the tell-tale streaks of discoloration, usually in the sapwood, which may denote wilt diseases. Leaves may be examined for signs of chewing insects, leaf miners, spider mites, leaf spot diseases, etc. Roots should be inspected for the symptomatic shoestrings of the honey mushroom fungus and for borers. That part of the trunk just above or below the ground level should be examined for evidence of old winter injury or rodent damage to the base of the tree. This is quite common and too frequently is overlooked. In fact, every visible part of the plant should be looked over carefully for parasites and injuries of all kinds.

* * *

TRANSPLANTING SMALL COLLECTED TREES AND SHRUBS

Let us suppose that the designer and plantsman are in agreement as to the various species to be moved and that a supply of available material has been located in a convenient place where digging conditions are favorable. Our next consideration is the actual digging, hauling, and planting of the trees and shrubs. In all transplanting operations emphasis should be placed on the quality of the work rather than quantity of production. Efficient work requires judgment, training, and experience, and the most successful transplanting operations are those in which the workmen as well as the supervisors thoroughly understand the principles which underlie the various steps so that modified techniques may be adopted when the necessity arises.

Digging

Digging methods will depend largely upon the rooting habits of the species and the individual. Plants grown in the open without much competition will tend to have more compact and better balanced root systems than those which are grown in forests and thickets where the sparse roots may extend for long distances and intertwine with the roots of neighboring plants. Very small stock may be moved readily without root-pruning, but medium to large sparsely-rooted shrubs and trees perhaps are more safely moved if they have been root-pruned a season or two in advance, as described previously. A certain amount of the root system is invariably lost in transplanting, but a root-pruned plant which has been encouraged to form a mass of fibrous roots close to the stem suffers less mutilation of its movable root system than one which has not been given this attention.

If plants are bushy or low-branched it is desirable to tie in the tops before any digging is done. This decreases the danger of breakage and makes digging and hauling easier. Burlap strips or cord may be used for this purpose, but care should be exercised to avoid tying so tightly that the branches will be bruised, broken, or split. (Fig. 5)

Small deciduous stock usually is moved bare-rooted, that is, without a ball of earth around its roots, but this does not mean that careless handling is permissible. Digging should be done with a sharp spade, starting far enough away from the plant to get a majority of the fibrous roots. Long anchor roots may be cut off with a sharp ax or root cutter since it is seldom practical to keep them intact without serious bruising or drying-out and the transplanted tree or shrub readily forms new ones. The important thing is to get as much as possible of the mass of fibrous roots, and careful forking out is necessary to keep and to avoid bruising them. After digging it will be found convenient to tie small shrubs into bundles of 10 to 25 plants for ease in handling. Heeling in such bundles preparatory to loading is a good practice.

Evergreens, even relatively small ones, always are more safely moved with a good ball of undisturbed earth surrounding the roots. Digging should be attempted only when there is a plentiful supply of moisture in the soil. When it is necessary to move plants during a period in which soil moisture is inadequate, stock to be transplanted should be thoroughly watered at least two days prior to digging.

Small balled stock may be dug and balled in the following manner. After cutting straight down all around and under the ball, with the face of the spade preferably held away from the plant, balls less than 15 inches in diameter may be broken loose by means of a spade used as a pry under one side of the ball. Deep roots encountered may be cut and the tree lifted out of the hole on to a piece of burlap which previously has been cut as shown in Figure 4.

FIG. 4
BURLAP CUT FOR WRAPPING

FIG. 5
SMALL EVERGREEN - BALLED AND BURLAPPED

When the soil is fairly tight or when the stock is to be moved just a short distance, the diagonal corners of the burlap may be crossed over the ball and tied. Loose folds may be tightened by means of nails used as pins. In loose soils or when hauls are fairly long, it is best to supplement the wrapping by means of heavy cord tied around the ball as in Figure 5. Larger balled stock should be trenched and the ball burlapped and laced tightly with cord or rope before breaking loose, as described on pages 39 and 40 of this bulletin.

The extent of root exposure that plants will withstand varies greatly with the species, temperature, wind, humidity, etc. Root and top drying is one of the major causes of death of transplanted stock and every care should be taken to prevent exposure especially on hot, dry, or windy days. Bare-rooted trees and shrubs may be covered with wet burlap as soon as they are dug or they may be heeled into the ground temporarily to protect the roots. Dipping the roots into a mud made from loam assists in keeping them moist but puddling in clay mud is inadvisable because of the danger of forming a hard shell on the outside of the roots which they will break through with difficulty. Balled stock may be kept from drying out by keeping the

burlapped balls sprinkled and by frequent syringing of the tops. If plants are to be held out of the ground for an appreciable time it is always good judgment to keep them in the shade and to cover the roots or balls with soil or to heel them in, regardless of the digging method.

Hauling

Distances, facilities, weather, and other local conditions vary so widely that it seems unwise to discuss in detail the hauling of transplanting stock between the digging and planting sites. A few cautions may be in order, however, to assure that losses from this cause will be kept at a minimum.

If the plants are to be transported for a considerable distance it is well to pack the roots of bare-rooted stock in wet peat moss, sphagnum, sawdust, or some other moisture-holding material. In any event, they should be protected from the wind and sun with wet burlap, canvas, or some other covering to prevent drying out en route. On long hauls, frequent watering will be necessary. The plants, whether balled or bare-rooted, should be packed tightly together to prevent their being thrown around and consequently bruised and broken. When stems or trunks are fairly long it is well to load the plants in a horizontal position to avoid breakage and bruising by overhead wires or other obstructions.

Upon reaching the planting site, the plants should be separated by species and sizes and heeled into the ground unless they are to be planted immediately. Before heeling in, bundles should be separated so that all roots come into contact with the soil. Frequent watering of heeled-in stock is good practice.

Planting the Tree or Shrub

Soil Preparation.--Someone has said that if the budget allowed $20 for a new tree, he would spend $1 for the tree itself and $19 preparing the soil to receive it. Perhaps if taken literally this might be considered an overstatement but it does focus attention on the necessity for adequate site preparation. Improper and inadequate soil preparation doubtless is responsible for as many losses in transplanted trees as any single cause and the experienced plantsman, who is familiar with the unavoidable growth difficulties and hazards faced by all transplanted trees, carefully avoids any unnecessary risks.

When the operation is extensive, when fairly good sized stock is used, or when the soil at the planting site is relatively poor, it is usually best to have the holes dug in advance of the arrival of the plants. This permits faster planting, keeps to a minimum the time the plants are out of the ground, and also allows the hauling in of good soil if the existing soil is of an improper type. It is always good practice to investigate the soil thoroughly.

Planting holes for deciduous stock should be sufficiently large to permit the roots being spread out in a normal manner without cramping or twisting. The sides should be straight and the bottom of the hole flat. Planting holes for balled stock should be at least 25 percent larger in diameter than the balls and deep enough to take the ball without breaking and allow several inches of good soil to be placed beneath it.

When it is necessary to plant trees and shrubs in soil which, by its nature, is unfavorable to growth the holes should be dug wide and deep enough so that from 6 inches to several feet of good soil may be replaced around the plant. The amount of soil preparation in normally poor soils should be limited only by the justifiable expense involved.

If it is necessary to plant during very cold weather the hole and soil for the backfill may be kept from freezing by keeping them covered with a mulch of manure, straw, or peat moss, or it may be desirable to store the soil in a warm place.

As the hole is dug the various types of soil encountered should be piled separately to facilitate planting. Sod should be lifted and used elsewhere, topsoil should be kept and piled carefully, while subsoil which is unfit for the backfill may be hauled away and replaced with suitable soil. Excavated soil should be so placed that it will not interfere with setting the plant in the hole. Soil for the backfill should be in good friable condition without lumps, sods, or large stones.

To assure the best possible root growth many experienced plantsmen are emphatic on the necessity for adequate humus content in the soil to be used as backfill. Jacobs (28) states that the uncertain qualities of topsoil may be improved by the addition of peat moss. He states, "The most favorable results are secured from peat moss when it is thoroughly mixed with the soil. This is best done by turning over the soil and peat several times—as in mixing concrete—before placing it in the trench around the tree." The quantity of peat moss advisable to use in the backfill will vary with the type of soil and the species being planted. Deciduous trees are frequently benefited by mixing thoroughly one part peat—by volume—with two to four parts of soil. For conifers and broadleaf evergreens somewhat larger quantities of peat may be used.

If the soil is too wet the hole may be left open for a time and provision made for artificial drainage, as described on page 45; if too dry the hole should be well wet down both before and after planting. If the site is too acid for the species of plants being used it may be sweetened by the addition of lime, wood ashes or both, but if too alkaline the soil may be acidified by the addition of peat moss, rotted oak leaves, (avoid green leaves), sulfur, or aluminum sulfate. The application of materials designed to change the acid reaction of soils should be based, of course, on actual soil tests. These are easily made with a simple testing kit.

Detailed directions for making tests for soil acidity accompany any good testing kit so it seems unnecessary to go into such details here. It may be stated, however, that acidity is expressed in terms of pH—the value of pH 7.0 representing a neutral reaction. Numbers below pH 7.0 represent acid reactions with acidity increasing as the numbers decrease. Numbers from pH 7 to pH 14 represent alkaline reactions with alkalinity increasing as the numbers get larger.

Tables showing the amounts of lime needed to increase the alkalinity of a soil and the amounts of sulfur or aluminum sulfate needed to increase the acidity of a soil have been carefully worked out by Chadwick (13) and are reproduced below.

Planting.--An important basic planting objective of both balled and bare-rooted stock is to set the tree or shrub as close as possible to the same depth as it originally grew. The plant should be placed in the hole on a prepared bed of good topsoil free from sod, lumps, or stones and adequate drainage should be assured or provided. The roots of bare-rooted stock should be carefully spread out in a natural position and any broken or bruised roots cleanly severed. The fine topsoil should be worked in around the roots so that each root is individually packed and no air pockets are left. The plant may be gently raised and lowered a little to assure a close contact of the roots with the soil especially under the root crown. When the roots are covered the soil should be tamped or stamped with the feet to prevent airpockets after which the hole is filled with water and allowed to settle. Then the hole is completely filled with topsoil without further tamping and a slight depression or saucer left around the tree to facilitate future watering. (Fig. 6) In late fall or winter planting it is well to omit the saucer around the tree if there is danger of ice forming in the depression and injuring the trunk.

TABLE I *

LIME REQUIREMENTS OF DIFFERENT SOIL TYPES OF DIFFERENT REACTION

PRESENT pH OF SOIL	POUNDS OF AGRICULTURAL GROUND LIMESTONE NEEDED PER 1000 SQUARE FEET TO RAISE:					
	SANDY LOAM SOILS		SILT LOAM SOILS		SILTY CLAY SOILS	
	TO pH 6.0	TO pH 6.5	TO pH 6.0	TO pH 6.5	TO pH 6.0	TO pH 6.5
6.0	-	23	-	41	-	58
5.5	23	46	41	83	55	115
5.0	46	69	83	124	115	173
4.8	55	78	97	138	138	196

TABLE II *

AMOUNT OF SULFUR OR ALUMINUM SULFATE NEEDED PER 1000 SQUARE FEET TO INCREASE THE ACIDITY OF A SILT LOAM SOIL

FROM pH	TO pH	SULFUR POUNDS	AL. SULFATE POUNDS		FROM pH	TO pH	SULFUR POUNDS	AL. SULFATE POUNDS
8.0	7.0	20	45		7.0	6.5	15	25
8.0	6.5	30	70		7.0	6.0	20	55
8.0	6.0	40	100		7.0	5.5	35	90
8.0	5.5	55	135		7.0	5.0	50	130
8.0	5.0	70	175		6.5	6.0	15	30
7.5	7.0	17.5	35		6.5	5.5	25	65
7.5	6.5	20	50		6.5	5.0	40	105
7.5	6.0	35	75		6.0	5.5	15	35
7.5	5.5	50	115		6.0	5.0	30	75
7.5	5.0	65	155		5.5	5.0	15	40

* Chadwick, L. C., Nursery Notes. May 1938. Columbus. (Ohio State University.) Mimeographed. Vol. 7, No. 7.

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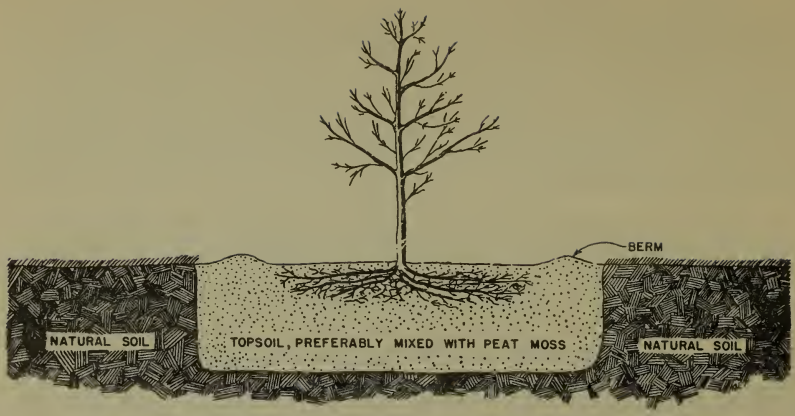

FIG. 6
CROSS-SECTION THROUGH SMALL TREE PLANTED BARE-ROOTED

The process of planting evergreens and other balled and burlapped stock is much the same as described previously but special care should be taken that the hole is well drained—especially for broad-leaved evergreens. If it is possible to remove the burlap before planting, this is advisable but if, because of the crumbling condition of the ball, this is undesirable it is well to cut the cords and loosen or slit the burlap before the backfill is made.

The balled tree is set on a well prepared bed of good topsoil and the hole gradually filled half way up the ball, constant tamping assuring good contact and elimination of air pockets. The hole may then be filled with water to settle the soil more firmly. When this is drained away the hole is completely filled and a slight depression or saucer left around the tree to facilitate watering. (Fig. 7)

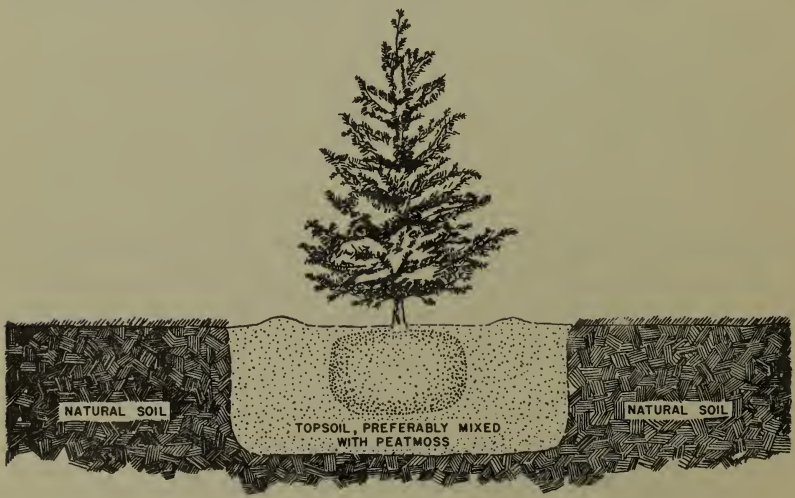

FIG. 7
CROSS-SECTION THROUGH SMALL EVERGREEN PLANTED WITH BALL

Balled stock, especially when dug in a damp clay soil, is occasionally received at the planting site with a rather hard shell on the outside of the ball. If this shell were left unbroken there would be a tendency to prevent or retard root growth so it is well in such cases to break the shell by stabbing it with a spading fork or to eliminate the shell by forking off some of the heavy soil from the root ends so as to surround them with better soil in which they may grow more rapidly.

The amount of water given any type of plant during planting depends, of course, upon the amount of natural moisture in the soil. In wet weather artificial watering may be decreased or even eliminated altogether, but if the soil is relatively dry sufficient water should be added to assure a firm bond of the root ball with the backfill and the surrounding soil. Initial watering should continue until bubbles cease to rise in the watering basin.

A word should be added here regarding the danger of planting balled stock in a clay soil where the ball is of a sandy type and, vice versa, planting clay balls in a sandy soil. In clay soils there is a tendency for excessive soil water to collect around and in the sandy ball and in sandy or excessively porous soils, for the soil water to drain away from the ball. The first-mentioned condition may be ameliorated by adequately draining the hole and the surrounding soil before planting and perhaps mixing some sand and peat moss in the backfill, while the second may be lessened by forking the outside of the ball at planting time and mixing well decomposed organic matter and clay loam in with the backfill. Whenever it is possible to do so, plants should be dug from soil which is similar to that of the planting site so as to avoid troubles of this kind.

Mulching

It is usually good practice, especially in fall planting, to provide a protective mulch of 2 to 6 inches of peat moss, straw, leaf mold, well rotted manure, or other coarse organic material over the roots of transplanted trees and shrubs, particularly evergreens. Such a mulch tends to keep the soil warmer, retards rapid changes in temperature, and cuts down evaporation. After the first year spring-planted stock does not need this protection as much, but the desirability of frequent cultivation of the soil surface cannot be overstressed. Mulches may be left on over the winter and worked into the soil in the spring. They may be replaced the next fall if necessary, although it is well to wait until the soil has frozen before mulches are applied to established trees and shrubs. Mulching is also discussed on pages 29 and 48.

Pruning

The pruning of transplanted trees and shrubs, especially those of wilding origin, is a necessary part of a planting operation (52). The purpose of such pruning is to compensate for

the root loss which the plant invariably suffers no matter how carefully the moving is done. Properly grown nursery stock and wildings with vigorous fibrous root systems will not require as severe pruning as the general run of deciduous wildings although the chances for success in transplanting many kinds of nursery grown trees are increased by judicious pruning. The equivalent of one-half to three-quarters of the buds usually should be removed from wildings at planting time. The extent of pruning is somewhat dependent upon the care and maintenance which will be given the plant in the future as well as the condition of the stock when received. When adequate watering and cultivation can be assured, drastic pruning is not so necessary as it is when the plant must depend entirely upon nature to supply necessary moisture. In establishing plantings of materials which frequently are subject to borers this type of injury sometimes may be avoided by cutting to the ground. Such drastic pruning is of especial value for semiwild plantings where watering may be difficult or impossible. As the new stems develop the process can be followed up by a selective pruning if single trunk trees are desired.

FIG. 8

PRUNING RELATIVELY SMALL TRANSPLANTED TREES

Shrub pruning should consist of the removal of the older canes and intersecting branches, and some heading back. Plants which have dried out somewhat or those which have a poor root system may be more severely treated, it being occasionally necessary to cut them entirely back to the ground at planting time. Cutting back to a formal outline rarely is desirable, since every effort should be made to retain the natural form of the shrub.

Unless a very low-headed tree is desired, the leader of a single-stemmed, deciduous tree rarely should be cut (unless the tree is excessively spindly) since such pruning would tend to spoil the ultimate shape of the tree, would detract from a

strong branch structure, and might cause a wound which would heal with difficulty. With the lateral branches of small trees these objections do not hold true. Heading back these branches brings the remaining branches closer to the main line of sap flow and provides a slender compact head which will readily branch out when growth starts. (Fig. 8) One of the common mistakes made in pruning small trees is to prune off the small twigs and buds in the center of the crown and along the stem thus leaving a sparse supply of buds at the branch tips. This process makes it difficult for the tree to provide nourishment for these ends and removes needed shade for the trunk; hence the branches literally starve to death for lack of circulation and the trunk is frequently damaged by sunscald and borers. It is far better—especially on oaks and maples—to leave the small twigs and buds along the trunk and head back the longer branches at pruning time. Later operations can include removal of unwanted growth along the trunk. It should be kept in mind that the only branch on a young tree which has a good chance to persist permanently is the leader—the laterals probably will die eventually from shading or they may need to be removed to shape the tree in certain locations. The shape of the crown of a small tree, therefore, is of negligible importance as contrasted with the necessity of making the tree live.

Since properly moved evergreens are transplanted with a ball of earth around the roots, less pruning of these is necessary at planting time. Although Chadwick (14) advises no pruning of fall transplanted evergreens, except broken roots and branches, until the following spring, practical considerations may indicate the desirability of pruning immediately under some conditions. When growth is starting is a good time to prune evergreens and at this time any broken, dead, or intersecting limbs may be removed and buds pinched off to curb any excessive growth or to thicken the plant. If an evergreen leader is injured during transplanting one of the top laterals may be tied up to take its place. The lateral may be held in place until established by means of a stake to which it is tied with a soft cord or raffia. Another method, sometimes used satisfactorily, is to disbud or prune all of the top laterals except one which will tend to grow upright and replace the leader. Pruning is also discussed on pages 30 and 49.

Guying and Staking

After trees are planted many must be held in position until the roots grow enough to assume this function. Very small trees and those growing in very sheltered locations may not need this help, but usually it is good practice to stake or guy all trees an inch or more in diameter or over five feet in height. (Fig. 9) Perhaps the simplest type of satisfactory bracing for smaller trees is a stake driven into the ground alongside the tree to which it is attached by means of binding material such as soft rope or a wire which has been run through an old piece of hose to protect the bark. Other types of stake supports are made from two stakes placed on opposite sides of the tree, or

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three stakes may be placed at equidistant intervals around the tree and united by cleats with the tree supported between. Tree boxes or metal guards, which serve a dual purpose of support and protection, frequently are used on street trees and those subject to mutilation.

Another type of support is furnished by guy wires or cables attached to the tree with lag screws or by running the wires around the tree through a piece of old rubber hose. Three properly placed guys usually are sufficient but it may be necessary occasionally on larger trees to use four guys to provide adequate stability. The ground end of the guys may be fastened to underground log or rock deadmen, steel anchors, or heavy stakes. Guy wires are kept tight by twisting the wires or by means of turnbuckles placed in the guys.

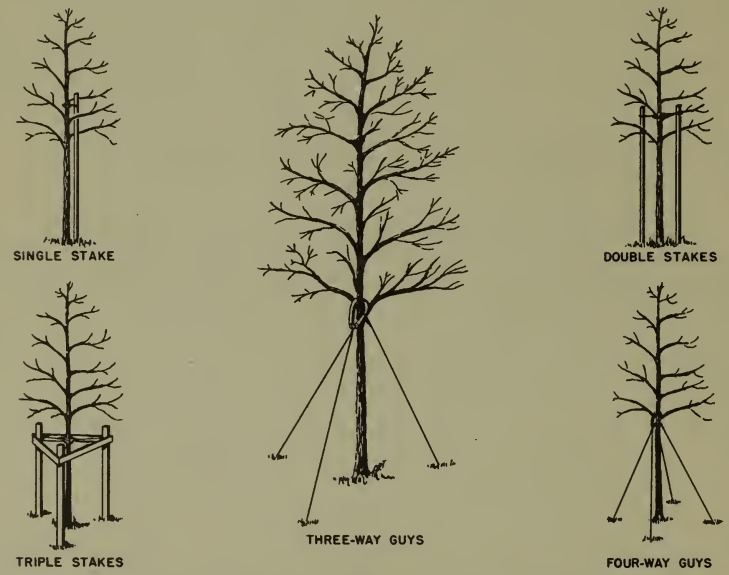


FIG. 9
METHODS OF STAKING AND GUYING YOUNG TREES

It should be noted that when planting is done in public places there is considerable danger that persons may trip and fall over guy wires even in places where they, from the public administration standpoint, have no business to be. Injuries need to be forestalled by fencing or by making the wires conspicuous in many locations where it is desirable to plant trees. Guying is also discussed on pages 30 and 47.

Wrapping

It is becoming more and more the practice to protect the trunks and larger branches of transplanted trees--particularly thin-barked species--by means of wrapping and such wrapping cannot be recommended too highly especially in those regions

where drying winds are severe. The wrapping serves a triple purpose. It retards transpiration and consequent drying out; it protects the tender bark from direct rays of the sun, thus preventing sunscald; and a paper wrapping helps to prevent borer infestation.

The principal material used for this purpose has been burlap cut into long strips but recently an especially prepared crepe paper has been developed which appears to have certain advantages over burlap. Both the burlap and the special paper are available in rolls of different widths and the material is wrapped on similar to a spiral bandage extending from the highest practical point on the trunk to the ground. (Fig. 10) The material is wrapped preferably from the top down and on large trees the wrapping is extended out on the branches. Each turn should be overlapped one-half the width of the material so that each point on the trunk is covered with a double thickness.

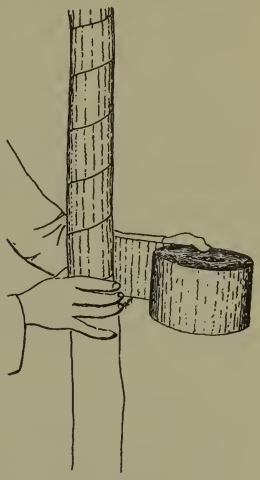


FIG. 10
WRAPPING THE TRUNK

It is advisable to reinforce the burlap or paper wrapping by binding it in place with a stout cord wound spirally in the direction opposite to that of the banding material. (26) The wrapping should be left in place at least two years or until it rots off.

Waxes.—Considerable experimental work has been done recently with wax as a substitute for wrapping (31). Under certain conditions and with some plant materials waxing appears somewhat promising but with those species normally subject to injury by oils it has been unsuccessful and it does not appear to be of value in repelling borers. At the present time waxing cannot be recommended generally for use in transplanting trees or shrubs in areas under the jurisdiction of the National Park Service. In the future, additional data and improvement of materials may indicate the desirability of more extensive use but waxing can never be considered a substitute for careful production and handling of transplanting material.

Maintenance

The amount and type of maintenance given transplanted stock will vary with the species, the condition of the stock at the time of planting, the season of planting, and fluctuations of temperature, precipitation, wind, etc., but regardless of the excellent condition of the stock or the efficiency of the planting operation, most trees and shrubs are in need of some attention until they are well established. It is possible to "kill a plant with kindness," however, and the maintenance should be intelligently applied.

Water.—The amount of artificial watering given a plant will depend upon the amount of natural soil moisture present. There is no more important limiting growth factor than adequate moisture but an oversupply is perhaps even worse than a deficiency. For practical purposes, most soils have a favorable amount of moisture if a handful can be squeezed into a ball that will maintain its shape when the hand is opened. Before any watering is done the competent plantsman will make careful tests to determine the existing conditions. An iron rod or a soil auger are useful tools for this purpose. The testing should, of course, be done in the soil mass in which the roots are imbedded. If this mass is dry, it may be necessary to drill a number of holes in it before watering to make sure the water goes where it is needed.

It is unwise to start watering deciduous trees too early in the spring before growth starts since keeping the soil moist is more helpful to root development than keeping it wet, and until the foliage is set very little water is required. In dry weather a thorough weekly soaking is preferable for most plants and localities to more frequent sprinkling. Light watering rarely penetrates deep enough to do any material good and tends to encourage the development of the root system toward the ground surface where it is more subject to damage. Transplanted stock, especially evergreens, should be watered thoroughly before the ground freezes in the fall so that the plants enter the winter with plenty of water around the roots.

Artificial watering should be continued at less frequent intervals through the second growing season since prolonged systematic watering, except during abnormally dry periods, may tend toward an artificially stimulated development which the plant will have difficulty in maintaining when left to its own resources. This is particularly true in semiarid regions.

To make sure that the plant receives all of the water intended for it and to serve as a collection basin for rain, it is well to maintain a shallow depression around the plant until it is well established. During wet seasons and before winter sets in frequently it is desirable to do away with this saucer since it may collect an excess of water or perhaps form an injurious collar of ice around the stem.

Frequent syringing of the tops of plants, particularly evergreens, often is beneficial in reducing water losses through transpiration and is helpful in washing off accumulated soot and red spiders. Such watering should not be done when the sun is shining, however, as the foliage may be injured severely under certain conditions.

The soil water in most sections of the country is favorable to plant growth but under certain conditions soil water may carry toxic materials in solution which are injurious to plants. Excessive quantities of boron, sulfur, and alkaline salts may fall into this category and the use of water containing injuri-

ous quantities of such materials should be avoided.

Fertilizers.—While there is no complete agreement, even among the experts, there is a definite trend away from the practice of fertilizing at the time of planting, many plantsmen having found that adequate water, good soil, and a surface mulch are of more value at this time and less dangerous to the plant than fertilizers although phosphates may be mixed with the soil at planting time with benefit to the plant. After growth is started, however, fertilizers properly applied in correct doses frequently are beneficial in helping the plant to become well established and regain normal growth.

Well rotted manure, tankage, cottonseed meal, bone meal, well composted leaf mold, or complete commercial fertilizers are generally satisfactory, but materials which will neutralize or sweeten the soil, such as fresh manure, lime, wood ashes, and bone meal, should not be used to fertilize broad-leaved evergreens or other species which require an acid soil. (14) Peat moss is an excellent soil conditioner and may be used freely at planting time or later, either incorporated in the soil or as a mulch, but it contains few or no readily available fertilizer elements.

Spring is probably as good a time as any for applications of fertilizer, although recent tests have shown fall to be as good or better under certain conditions and with some species. It may be forked into the ground, placed in driven or drilled holes, or distributed underground by means of air or in a water solution. Commercial fertilizers may be applied at the rate of 2 to 3 pounds per 100 square feet for bed plantings and 3 to 5 pounds per inch of trunk diameter for larger stock. Formulae of 10-8-6 and 10-6-4 frequently are recommended but several others have been found satisfactory in use.

Mulches.—Mulches of organic material such as peat moss, rotted manure, leaf mold, straw, etc., extending well beyond the root area may be left on the year around if pulled back from the base of the trunk to avoid rodent injury during the winter season. Mulches on deciduous plants should be loosened occasionally to avoid the danger of packing and may be forked into the soil in the spring with benefit to some plants. Most authorities feel that mulches on ericaceous plants should not be disturbed from year to year and after the third year an unbroken mulch is desirable for most woody plants. Others point out that even ericaceous plants may suffer poor growth if the mulch is so compact and tight as to prevent proper aeration and consequently advocate very light loosening in such cases. A new material coming into favor as a mulch is glass wool. It is light in weight, may be used for several years, admits light to the soil but keeps soil temperature moderated, discourages rodent activity, and has other advantages well worth investigating. Mulching is also discussed on pages 23 and 48.

Cultivation.—Frequent surface cultivation of the soil

around most plants, especially during dry weather, is one of the best ways to keep the soil in good condition, reduce evaporation, promote root growth through increased aeration, and keep weeds under control, especially where mulches are not practicable. An effort should be made to keep an area around recently transplanted stock cultivated and free from weeds and grass, as such growth robs the soil of nutrients and moisture needed by the plants.

Guys.—Trees need straightening occasionally and guy wires should be tightened or adjusted from time to time so as to keep them taut but at the same time to prevent constriction. Stakes may be loosened by frost action and should be redriven as occasion requires. After two growing seasons it is usually possible to remove guys and stakes. Guying is also discussed on pages 25 and 47.

Wrappings.—Trunk wrappings occasionally become loosened and need to be adjusted or reapplied. They may be left on for a 2-year period or until they rot off or become unsightly.

Pruning.—Occasional pruning may be required by a plant to curb an unruly branch, remove broken branches, and to eliminate dead wood. Trunk sprouts which have been left on trees for shading purposes may be removed gradually and low lateral branches may be removed when and where this seems desirable to shape the tree. No attempt should be made to formalize the development of a shrub unless it is being trained for a specific purpose as in topiary work or hedges. Pruning is also discussed on pages 23 and 49.

Insects and Diseases.—Constant watch should be kept for disease and insect infestations. Plants generally are more susceptible to attack and serious injury from these causes when they are in a weakened condition following transplanting; hence diseases and insects should not be permitted to gain a foothold. Necessary preventive or control sprays should be applied as required. Standard spray formulae for this purpose are given in Tree Preservation Bulletin No. 6. (54)

Screens.—Winter and early spring winds may be very detrimental to deciduous plants in cold windy regions where evergreens will not grow and in regions where evergreens can be grown injury may result in the spring before the ground is thawed as such winds cause excessive transpiration from the foliage before the roots are able to function and restore the water loss. To prevent this and other winter and spring damage it is well to protect tender evergreens from such injury by erecting screens to shield them until after the early spring winds have subsided. (Fig. 11) These should be set up close to the plants but not actually touching them, as the formation of ice on the screens might injure the foliage at points of contact.

Suitable screens may be made of burlap or canvas stretched

on a wooden framework or use may be made of the rustic woven straw or stake screens now available on the market. Small evergreens may easily be shielded by setting wooden boxes over them preferably with the leeward side removed to admit air and light. Some degree of protection also may be obtained from pine branches or discarded Christmas trees.

FIG. II
TYPES OF WINTER PROTECTION FOR TENDER EVERGREENS

BIG TREE MOVING

Although the basic principles involved in moving large trees are in most instances essentially the same as for handling small trees and shrubs, the greater masses and weights inherent with large sizes require quite different handling. The techniques and types of equipment used for big tree moving vary widely not only in different parts of the country but between

FIG. 12. AN EARLY TYPE OF TREE MOVING MACHINE
TAKEN FROM "THE PLANTER'S GUIDE" BY SIR HENRY STEUART. 1828

individual tree movers as well. Much of this individuality presumably is a result partly of varying local conditions of soil, temperature, humidity, precipitation, etc., and partly of the experience and training of the operator. It is safe to state, however, that no one method or apparatus is universally applicable.

While it would be obvious presumption on the part of the author to recommend one method or group of methods over another, observations in many parts of the country could not but lead to the conclusion that in certain instances present methods are in need of improvement and it is hoped that a careful study of the methods mentioned or outlined will be of some assistance in improving local practice, particularly in those areas where few experienced plantsmen are available or where tree moving is relatively new. The discussion which follows will touch briefly on some of the more important methods in use today.

Bare-rooted vs. Balled Trees.—Some years ago most species were moved bare-rooted; that is, with as much earth as possible removed from the root system. In spite of all possible care, however, the roots frequently were bruised or dried out to a serious and sometimes fatal degree in the slow and expensive process of combing out, and too many of the vital fibrous roots were lost.

Under some conditions—where the soil is light--operators may use a partial bare-root, partial ball method of moving trees. This practice was and still is fairly successful for some species if carefully done but most modern arborists have found it more satisfactory to move large trees with an appreciable amount of the root system encased in an unbroken ball of earth. The roots which protrude usually are trimmed off flush with the ball. While this practice results in the loss of a considerable portion of the root system, if a sufficiently large ball is dug and other factors are favorable, enough undisturbed roots are retained inside the ball to enable the tree to recover quickly from the shock of moving and to extend its root system into its new environment.

The methods by which the ball is protected so as to preserve its integrity vary considerably. Much depends upon the season of the year, the type of soil, and type of equipment available.

Frozen Ball.—Some tree movers in the northern regions prefer to move trees in the winter with the ball frozen solid. It has been a rather common practice in some parts of the country to trench around the tree during extremely cold weather and by leaving the ball exposed for a time to low temperatures a frozen block of earth and roots resulted and permitted moving with little or no wrapping. This practice, although fairly efficient mechanically, could not help but be detrimental to at least a portion of the deep roots which normally are not subjected to freezing; consequently the frozen ball method of

large tree moving is becoming less prevalent. The roots of some species--oak and maple for example--are more quickly injured by exposure to frost than others such as elm. The frozen ball method should not be attempted with those species likely to be injured by freezing.

Some recent experimental work has been done with the use of dry ice (solidified carbon dioxide) to freeze the ball. The practice has shown considerable applicability, particularly when a sudden thaw has loosened the ball of a tree in transit, but it has the same theoretical objection as a normally frozen ball, namely, damage to roots.

Gumbo Ball.--In certain localized parts of the country, such as the "gumbo" areas of Texas, it is possible to move fairly large trees with no preparation of the ball beyond the digging of one of a suitable size. The earth is of such a sticky consistency when moist, and bakes so hard when dry, that it forms a very cohesive mass about the roots which can be handled in a relatively rough manner without breaking.

Tree Boxes.--An interesting tree moving technique is used quite generally in certain sections--notably California--to the almost complete exclusion of other systems. To use this method it is necessary to prefabricate units of heavy boards made up in four sections each having the shape of an inverted truncated triangle. These are designed so as to fit tightly together to form the sides of a box which is held together with long bolts. (Fig. 13)

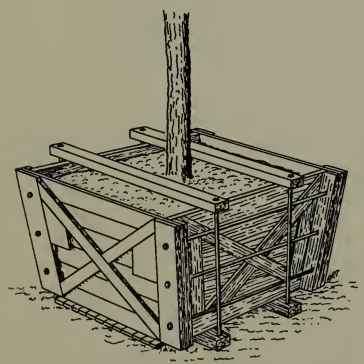


FIG. 13
TREE BOX - ASSEMBLED

The ball is dug to the exact shape and size of the box to be used and the box sections are clamped into position. The whole unit is then held in place by the use of jacks or otherwise while the ball is being undermined and the bottom boards slipped underneath and fastened. Jacks again may be used to lift the tree--box and all--out of the hole. A-frames or derricks mounted on trucks, or tripods and block and tackle are alternate common methods of removing a boxed tree from the hole.

It is a frequent practice--when time permits--to side box the tree and leave it in the ground for later moving. This procedure essentially is root-pruning and permits the development of a mass of fibrous roots inside the box which will enable the tree to establish itself more readily when finally moved to its new location. The method followed by the Los Angeles Park Department in this case is to side box the tree on

three sides at the first operation, each side being about 3 to 6 inches less than the box size. The intermediate space is filled with a mixture of leaf mold and good light soil for the purpose of encouraging fibrous root development. Watering is provided and the fourth side of the box put on thirty to sixty days later. If in the summertime it is thought well to wait another thirty days before putting on the bottom of the box and moving the tree. Presumably, it might be well to augment this treatment by crowbar fertilizing inside the ball.

Another rather common commercial practice is to assemble the boxed trees into "yards" where they are stored, watered, and fertilized above the ground for a few months or even years until they are sold and planted.

DRUM LACE AND PLATFORM METHOD

Because of the relatively low cost and easy availability of equipment needed and the ready adaptability of the method to conditions found in most parts of the country it is thought well to describe in some detail the technique of moving relatively large trees by what we may call the "drum lace and platform" method. The technique of digging, wrapping, lacing, and platforming described varies, of course, from that found satisfactory by many experienced plantsmen but since space limitations prevent describing all methods and variations used it seems wise to confine the discussion to one system which is generally applicable. This method is satisfactory for handling trees up to 12 inches in diameter or larger trees if they do not have to be tipped in transit. (Fig. 19)

Equipment

The essential equipment needed for moving a tree by this method is all easy to obtain or make and includes a wooden platform, rope of various sizes, a mat made of rope or belting, a supply of open iron links, burlap, wire rope or cable, winch and motive power, picks, shovels, skids, rollers, planks, crowbars, etc. A truck, trailer, tractor, wagon, or some other means of transporation is, of course, necessary also. These materials and equipment may be used over and over again as there need be no loss of equipment except that worn out by ordinary use.

A satisfactory platform (Fig. 14) is made of 2-inch dressed lumber which is built up of two or three plies—the plies being firmly nailed at right angles to each other. The platform may be square or the corners may be cut off making it octagonal—the proper size being approximately the same as the diameter of the ball which is to be handled. Provision for fastening the tree to the platform may be provided by iron rings run through U-shaped strap irons (Fig. 15) which are countersunk and riveted to each corner of the platform, or wire loops may be substituted for the rings. (Fig. 16)

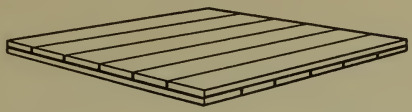


FIG. 14
TREE MOVING PLATFORM

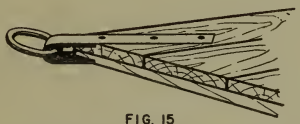


FIG. 15
PLATFORM CORNER WITH IRON RING

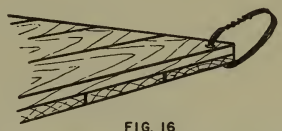


FIG. 16
PLATFORM CORNER WITH WIRE LOOP

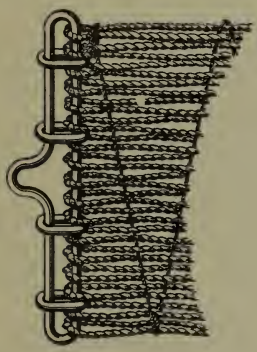


FIG. 17
ROPE MAT
WITH BELT IRON
REINFORCED WITH
OVAL IRON RINGS

FIG. 18
BELT IRON
OPTIONAL DESIGN
REINFORCED WITH
WELDED BRACING

FIG. 20
IRON STAPLE
FOR HOLDING TOP ROPE
TEMPORARILY

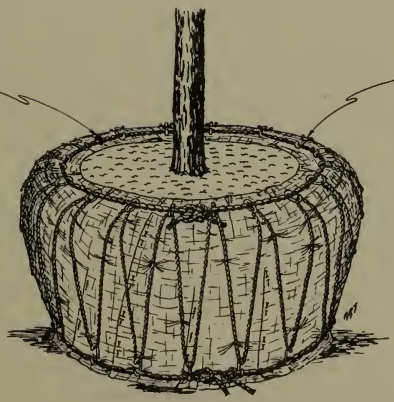


FIG. 19
TREE BURLAPPED AND LACED

FIG. 21
IRON LINK
TO SIMPLIFY LACING

A rope mat (Fig. 17) for handling large-sized balls may be made as follows: First, two belt-irons of 1-inch round iron are made up by a blacksmith who should include four tightly fitting links for each belt-iron, so that the links will prevent the irons spreading out of shape, or cross bracing may be welded in for this purpose. (Fig. 18) These are held about 12 feet apart, the proper distance being about half the circumference of the ball to be handled. A continuous length of 3/4-inch diameter rope is wound back and forth between the belt-irons to form the warp of the mat and another rope of about 1/2-inch diameter is then woven into the warp to form the woof. Mats for use on relatively small balls—from 3 to 5 feet in diameter—may be made about 8 feet long of 5/8-inch and 3/8-inch diameter rope with 3/4-inch round iron used for the belt-irons. As a substitute for the rope mat, a belt of wide webbing may be used quite satisfactorily.

A dozen or so large staples (Fig. 20) will be found useful to hold the top rope temporarily in position while the ball is being laced. These can easily be made of 1/8-inch round iron or heavy wire if not available ready made.

The use of open links (Fig. 21) simplifies both the lacing and unlacing of the ball. The links can be made of 1/2-inch round iron and a sufficient quantity should be available to permit the use of three times as many links as would be needed to space them every 10 inches around the top rope.

Preparing the Ball

Before any digging is done scrub growth around the tree should be cut away and any low branches tied up so as to prevent interference with the operation.

When the site is cleared the ball size must be determined. Some tree movers use standardized formulae for determining the size of ball and these various formulae will result in balls which are 6 inches to 1 foot in diameter for each inch of trunk diameter. Most experienced arborists, however, have found that no one formula is advantageous in all instances and depend upon local conditions to determine the proper size ball for a particular tree.

Factors influencing the size and shape of the ball will include the rooting habits of the plant, the character of the soil, the species, location, and size of tree, the amount of soil moisture, the general vitality of the tree, and, last but by no means least, the type of maintenance which the tree will receive.

Rather than try to estimate a suitable ball size by using a formula, it is considered better practice to start digging at a greater distance from the trunk than need be and then cut the trench down on the inside as the roots found may justify. While large roots frequently must be cut in the operation it

should be remembered that the roots most essential to the continued health of the tree are the fibrous feeder roots. The outside of a properly dug ball of a tree which has not been root-pruned will show a good ratio of cut root ends, ranging from minute fibrous roots to those of pencil size or even larger. If nothing but fibrous root ends are revealed, the chances are the ball is too wide, but if no fine roots can be seen the ball is probably too small in diameter.

The purpose of the ball of earth is to protect the greatest number of roots within the least soil mass. In some cases a shallow ball with a greater diameter would contain a greater percentage of the root system than a ball of similar volume and weight, but of smaller diameter and greater depth.

Although exceptions can be found readily, it is more or less generally true that trees growing in moist or wet fine clay or silt will tend to have more shallow, widespreading root systems and hence may be moved successfully with shallower but wider balls than trees found in dry, loose soils. More often than not, coniferous trees require a deeper ball than deciduous trees which tend to require a wider but more shallow ball. Vigorous trees may be moved with balls of less volume than those about which there is some question as to vigor and vitality. When expert maintenance and constant attention can be assured for the transplanted tree and other conditions are favorable, it is reasonably safe to cut down somewhat on the size of the ball but where there is any question as to the future attention the tree will receive, such a procedure is not to be considered.

Ever since trees have been transplanted commercially there have been attempts to standardize a ratio between ball size and tree size to serve as a basis for specifications for competitive bidding. The workability of such ratios, as might be supposed, has been proportionate to the ability and experience of those who prepared the specifications. The latest endeavor along this line was worked out by an experienced committee of the American Association of Nurserymen and tentatively approved by that organization in 1939. The approved table of minimum ball size presumably is intended to apply to nursery grown stock or trees which have been adequately root-pruned or transplanted and cannot safely be assumed to be applicable to wildings. In the opinion of the author and some of his collaborators certain changes appeared desirable and a slightly modified table of minimum ball sizes appears below as Table III. It should be emphasized that the ball diameters given are intended to be minimum sizes and not average or maximum.

The tree mover should consider that while it is important to retain as much of the root system as possible, an excessively large ball adds to the weight needlessly. In order that some idea may be gained of the weight of earth a chart has been prepared showing the average weights of tree moving balls. These figures do not give weights of trunk and branch structures.

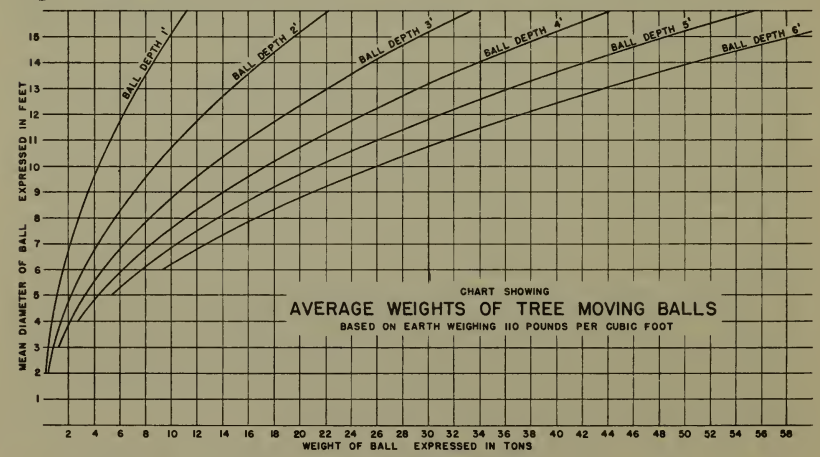
TABLE III *

MINIMUM BALL SIZES

TYPE 1 COLUMNAR CONIFEROUS EVERGREENS		TYPE 2 BROAD CONIFEROUS EVERGREENS		TYPE 3 SPREADING EVERGREENS, CONIFEROUS AND BROAD-LEAVED		TYPE 4 SHRUBS AND SMALL TREES		TYPE 5 STANDARD SHADE TREES	
HEIGHT OF PLANT	DIAMETER OF BALL	HEIGHT OF PLANT	DIAMETER OF BALL	SPREAD OF PLANT	DIAMETER OF BALL	HEIGHT OF PLANT	DIAMETER OF BALL	DIAMETER OF TREE	DIAMETER OF BALL
18-24"	11"	18-24"	11"	18-24"	11"	18-24"	11"	1-1½"	18"
2-3'	12"	2-3'	13"	2-2½'	13"	2-3'	12"	1½-1¾"	20"
3-4'	14"	3-4'	15"	2½-3'	15"	3-4'	14"	1¾-2"	22"
4-5'	16"	4-5'	17"	3-3½'	17"	4-5'	16"	2-2½"	24"
5-6'	17"	5-6'	19"	3½-4'	19"	5-6'	18"	2½-3"	28"
6-7'	19"	6-7'	21"	4-5'	21"	6-7'	20"	3-3½"	33"
7-8'	21"	7-8'	24"	5-6'	25"	7-8'	22"	3½-4"	38"
8-9'	22"	8-9'	26"	6-7'	29"	8-9'	24"	4-4½"	43"
9-10'	24"	9-10'	28"	7-8'	32"	9-10'	26"	4½-5"	48"
10-12'	27"	10-12'	31"	8-9'	38"	10-12'	29"	5-5½"	53"
12-14'	30"	12-14'	35"			12-14'	32"	5½-6"	58"
14-16'	33"	14-16'	40"			14-16'	36"	6-7"	65"
16-18'	37"	16-18'	44"					7-8"	75"
18-20'	40"	18-20'	48"					8-9"	85"

* Prepared from smooth curves constructed from data taken from report of Standardization Committee, American Association of Nurserymen (except type 5, which is based on 1" diameter of trunk equal to 10" diameter of ball.)

According to the results of thousands of tests made in recent years by the National Park Service Engineering Laboratory, the weight of soil will vary from 90 lb./cu.ft. to 125 lb./cu. ft. depending upon the soil texture, the amount of moisture present, and the degree of compaction. The average soil encountered in tree moving operations will average about 110 lb./ cu.ft. while the average specific gravity of soil is about 2.65. The following chart has been based on these figures using the volume of a cylinder as a basis for computation. It should be noted that the average diameter of the ball is used, not the top diameter.



Another method of computing the weight of a balled tree has been worked out by W. C. Griffing for the committee on standardized grading for the American Association of Nurserymen and published in the October 1, 1939, issue of American Nurseryman. "To figure the weight of balls, square the ball's width (inches), multiply by its depth (inches), subtract one-

third from the total, multiply the remainder by .075 pounds and the resulting figure is the weight of the ball." Computations made by this method give results substantially the same as found on the above chart although based on an entirely different method of computation.

Digging.—Sometimes the sod, if any, or surface soil in which there may be no roots is cleaned off to a point just above the roots. In this way it is possible to lighten the ball—sometimes by a half ton or more— without loss or injury to the root system.

Before digging is started it is well to determine the best location for the ramp up which the tree will be pulled out of the hole. This, of course, should be on the most accessible side of the tree and for easy handling of large trees the ramp should be dug a foot or two wider than the ball and at a slope of about three or four to one.

A rope with a loose loop placed around the trunk, with a stake or shovel tied at a given point, will give the plantsman a compass with which to strike off a true circle for the ball. The marking is made perhaps 6 inches beyond the final perimeter desired to permit such shaping and trimming of the ball as may be required.

The trench should be made with vertical sides and wide enough to permit plenty of freedom of action in digging and lacing the ball, as working in a cramped position slows down the operation. The depth of the trench will depend entirely on where the roots are found. Digging should continue straight downward at least 6 to 8 inches beyond the depth of the lateral roots of a tree which has a shallow or laterally rooted type of root system and somewhat deeper on a tree which has developed roots which tend to be deeper. No hard and fast rules can be laid down for ball depth any more than they can for ball diameter. Experience and observation must be depended upon in each instance. As roots are encountered by the digger they should be trimmed off flush so as not to disturb the ball or interefere with digging.

After the ball is dug with vertical sides it is desirable to taper it inward from the top to the bottom so that the bottom of the ball will be 6 to 12 inches less in diameter than the top. The work of shaving the sides should be a gradual process so as not to disturb the ball unduly and it is best to work with the back of the spade against the ball in this case. As roots are encountered they should now be trimmed off carefully with clippers, long handled pruners, or a saw and the cut ends painted with a good wound dressing. Any rocks encountered, which project partially from the ball, should be removed entirely and the hole plugged smooth with damp loam or clay. With the sides properly tapered and as smooth as possible, the top edge of the ball should be rounded off as the pressure of the lacing would crumble a sharp edge.

Burlapping.—The ball now should be ready for a protective jacket of burlap. Gunny sacks may be used for this purpose but long strips of strong burlap are better and easier to use if available. If bags are to be used they should be slit open and laid over the ball one after the other so that they overlap and cover the sides of the ball completely to within 4 inches of the bottom of balls to be cut with a cable and clear to the bottom of balls to be broken off by tipping. The burlap should extend 1 foot inside the top perimeter. If a burlap strip is used this should be wrapped around the ball in a similar manner. When the burlap is in place it may be fastened and tightened by doubling over the slack material and pinning with nails until every loose fold is eliminated. If the tree is to be transported in a horizontal position the top of the ball should be burlapped in a similar manner. Balls over 5 feet in diameter should be double burlapped as a safety precaution, the second layer of burlap being applied as the first.

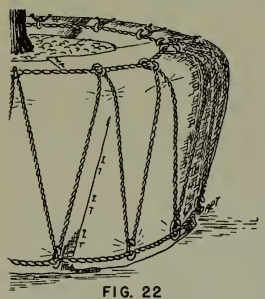


FIG. 22
DRUM-LACED BALL

Lacing.—In general, a good job of ball lacing resembles the type of lacing used on a drum, but instead of the side lacing being applied to drum heads it is hooked into ropes tied around the top and bottom of the ball. (Fig. 22) These two ropes receive a heavy strain and consequently should be strong. For balls up to 3 feet in diameter the top and bottom ropes may be 1/2-inch in diameter, while large balls may require ropes of 1-inch diameter for this purpose. Side lacing may be of 1/4-inch rope for balls up to 3 feet, but 1/2-inch or 5/8-inch diameter rope should be used for larger sizes.

An innovation which was first used in National Capital Parks simplifies the process of drum lacing. This timesaver consists of open iron links or double hooks which are used to connect the drum lacing with the top and bottom ropes. (Figs. 19-21) This avoids the necessity of pulling the entire length of the lacing rope through the bottom and top ropes each time or threading the top and bottom rope through the temporarily held lacing rope.

The lacing procedure, when links are used, is relatively simple. The bottom rope is placed around the ball just above the lower edge of the burlap and loosely knotted with a bowline in one end and a half hitch through it. The top rope is similarly placed around the top of the ball to form a ring about 6 inches inside the perimeter but with the ends tied tightly together in a square knot. It is a good idea to hold the latter rope in position temporarily by means of a few large staples (Fig. 19-20). These can be removed after the drum lacing is tightened. Open links are then hooked into the top rope evenly 10 to 15 inches apart and a similar number is hooked into the bottom rope, interspaced with the top ones. A loop is tied near one end of the lacing rope which is hooked over one of the

top links and then is hooked alternately over the links in the bottom and top ropes around the ball until the original link is reached where it is tied temporarily. The bottom rope is now snugged up as tightly as possible and tied firmly, after which the slack is taken out of the lacing rope. By working gradually twice around the ball it is possible to achieve a very tight lacing and tightness is absolutely necessary.

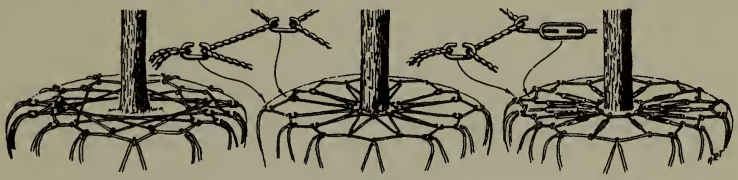


FIG. 23 FIG. 24 FIG. 25

METHODS OF TOP-LACING THE BALL

If the ball is a large one or if it is to be tipped in transit it is good practice to place additional lacing over the top of the ball. Such lacing may be accomplished by running a rope back and forth across the top of the ball hooked at each turn to an iron link in the top rope interspaced with the links used for drum lacing. (Fig. 23) Another top lacing method is to place a central ring rope a few inches away from the trunk in which links are inserted to correspond with interspaced links in the top rope. The lacing rope is then hooked between these similarly to the spokes of a wheel. (Fig. 24) A third method of top lacing is to hook large-sized turnbuckles between the central ring rope and the top rope. The latter method has the advantage of ready adjustment. (Fig. 25)

Some experienced tree movers prefer to use wire for wrapping the ball in preference to rope lacing. (Fig. 26) Stiff hog-wire fencing is preferable to other types for this purpose. In order for the fencing to conform to the taper of the ball it is necessary to cut the ends diagonally so that they will lap smoothly. After the ball is burlapped in the usual manner, a section of the fencing is wrapped around the ball and the wire ends spliced together. The wire is tightened by kinking as necessary in order to draw it tightly against the ball. In the case of large balls—perhaps 8 feet in diameter or over—usually it is desirable to supplement the wire wrapping with rope lacing for added strength and maneuverability.

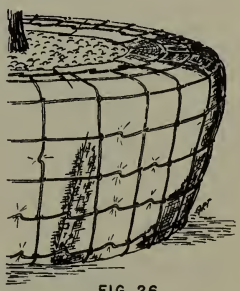


FIG. 26
WIRED BALL

Platforming

There are two principal methods used in getting the wrapped ball on the platform. A small tree—up to 3 feet in diameter—is broken loose from the supporting pillar of earth by undermining the ball on all sides and then tipping it over by pressure applied to one side of the ball. The exposed bottom

of the ball is then shaved smooth and any roots are cut off cleanly. Loose earth is removed from the bottom of the hole and the platform inserted beneath the ball which is then tipped upright again on the platform. If the ball is not centered on the platform it may be twisted around by direct man power or by applying a rolling hitch around the ball to pull it into position. The ball may then be lashed in place by means of ropes run across the top of the ball and fastened to the corner rings or wire loops on the platform.

Larger trees are platformed more easily by cutting the ball loose with a cable. To do this satisfactorily some form of pulling power is necessary such as a hand or power-driven winch mounted on a truck or a tractor. To this source of power is attached a strong steel cable with a large hook on the end. The cable is placed around the back of the ball well below the bottom rope and the hook is brought around and hooked over the cable forming a noose (Fig. 27) or anchored over the end of the platform. Power is then applied to the cable which cuts the ball free, severing any roots encountered.

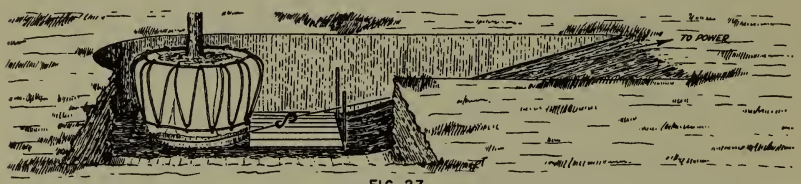


FIG. 27

DIAGRAMATIC SKETCH SHOWING METHOD OF CUTTING THE BALL WITH A CABLE

Power is again used to pull the ball onto the platform which is placed at the bottom of the ramp against the earth below the ball. It is necessary to drive crowbars through the upper rings of the platform or against the platform to hold it in position. The rope mat (page 36) is placed in back of the ball with the belt-irons hooked to a short piece of cable which in turn is hooked into the cable attached to the winch or tractor. (Fig. 28) As a means of reducing friction it is a good idea to mix some mud on top of the platform so that the small

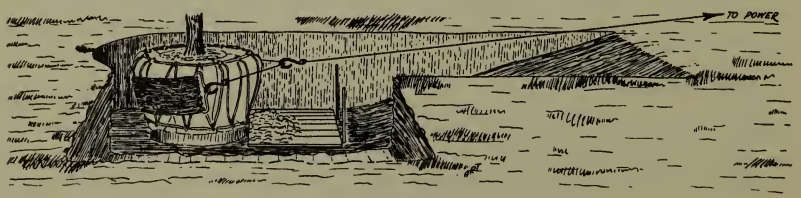


FIG. 28

DIAGRAMATIC SKETCH SHOWING METHOD OF PULLING THE TREE ON TO THE PLATFORM

soil particles will tend to act as ball bearings for the ball. When this is done power can be applied to the cable and the ball pulled gently onto the platform until it is centered. The crowbars holding the platform may then be pulled out and the ball lashed firmly to the platform by means of rope strung through the platform rings and over the ball or by means of

turnbuckles attached to the links used in lacing the ball and to temporary lag hooks screwed into the top of the platform.

Loading

If the platformed tree is relatively light it is a simple matter to drag it out of the hole and on the truck with block and tackle, but a heavy ball may be loaded easily if properly handled. Before the platform is moved the front end may be pried up and ends of two planks inserted beneath it. Between the planks and platform a length of 2- to 4-inch diameter pipe should be inserted crosswise to act as a roller. The winch cable is then attached to the platform rings or hooked over the back side of the platform and the power applied. As the platform rides up on the roller successive rollers are placed beneath it on top of the planks.

When especially large trees are platformed it is desirable to place planking and rollers beneath the platform before the tree is pulled on. Considerable skill and ingenuity frequently are required to anchor the platform and winch truck satisfactorily and to rig the load line for an extra heavy pull. An adaptation of the blocking and rigging illustrated in Figure 29 may be found useful in some cases.

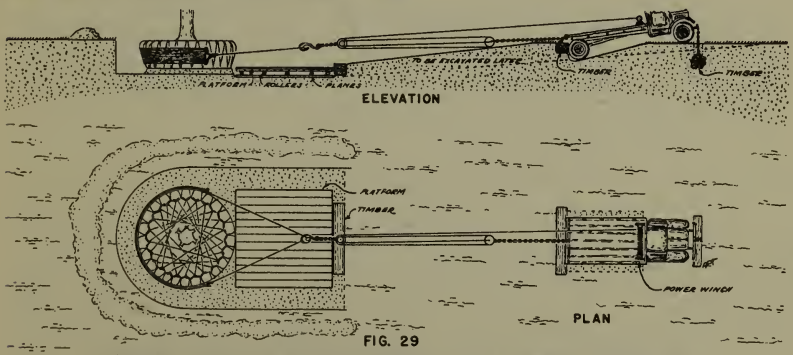


FIG. 29

DIAGRAMATIC SKETCH OF RIGGING USED TO PLATFORM A LARGE TREE

CONTINUED ON P. 43

Skid bars made of heavy timbers are useful in getting the tree upon the truck or trailer. The ends should be trimmed to fit against the ground and the truck and have the truck ends equipped with strap iron hooks to fit into stake holes and the lower ends reinforced with strap iron to prevent splitting. Planks properly supported by blocking may be used if no prepared skid bars are available.

If the tree is too high to be carried upright on the truck it may be tipped over after loading, using the winch to lower it gently. The trunks and/or tops of heavy trees when carried horizontally should be supported in transit by means of blocked up support, well padded and firmly lashed to prevent bruising. The rope sling hung from the side boards of the truck may be useful for supporting the trunk or crown.

Hauling

The method used to haul heavy trees from one place to another will depend on the distance of the haul, the facilities at hand, and the difficulties anticipated en route. It is unnecessary to load trees on vehicles if they are to be moved only a few rods. Planking and rollers are sufficient in many instances but if a long haul is required some type of vehicle will be necessary. If the operation is an extensive one or heavy loads are to be transported a low trailer will be found advantageous; otherwise an ordinary platform truck of adequate capacity is satisfactory.

Loads up to 3 tons are fairly safe for standard platform trucks, but heavier loads require special equipment. When heavy loads must be transported over public streets or highways the person in charge should make sure that all regulations covering such hauling are complied with so as to avoid any damage to the highway or highway users and to prevent complications with the authorities. Suitable safety precautions such as the use of red flags or danger signs or posting guards ahead on narrow roads and at blind corners should not be overlooked.

Routing should be planned carefully in advance of actual moving to make sure that road and street clearances are adequate and to make provision for the assistance of power or telephone company employees for temporary removal or raising of service wires when necessary. Considerable tying in of wide spreading tops frequently is required when transporting large trees through streets or along highways.

Preparation at Planting Site

The general basic requirements for the preparation of the planting site, as described on page 19, apply to big trees as well as small trees and shrubs. Because of the proportionately greater difficulty of establishing large trees a few extra precautions should be observed. It is always a good plan to prepare the hole or holes for big tree planting well in advance of digging, particularly if the operation is a large one, in order that the trees may be out of the ground as short a time as possible and to enable the plantsman to provide suitable soil, drainage, mulch, guying materials, and other planting conditions and facilities.

Digging the Hole.—As a general rule, holes for balled trees should be dug a minimum of 2 feet wider than the ball. This permits backfilling with at least a foot of good soil all around. Holes dug in poor soil should be proportionately larger and deeper so as to permit an underfill of good soil beneath the tree. The sides of the hole should be vertical while the bottom may be sloped toward the tile in heavy soils where such drainage is necessary. A suitable ramp should be provided for platformed trees and should be dug so as to be convenient and to make turning of the tree in the hole unnecessary. The

point of orienting the tree should be considered in digging the hole.

When trees are transplanted with tree-moving machines it should be remembered that they usually produce a more pleasing appearance when viewed from a certain direction as few indeed are perfectly shaped. This point should be kept in mind in selecting the tree and in determining the side to which the mover should be attached and the direction from which it should be unloaded in order to avoid unnecessary handling.

Excavated soil should be piled so as not to interfere with the planting operation and soils of different types should be kept separate. Soil which is unsuitable for the backfill should be hauled away and replaced with a suitable type.

Drainage.--Suitable drainage is a vital factor in the survival of transplanted trees. It is probable that as many or more trees are lost because of poor drainage as by lack of sufficient soil moisture. This is especially true, of course, in heavy clay soils and those with a compacted subsoil or hardpan beneath. Less trouble is experienced with sandy soils which normally are drained adequately.

Artificial drainage may be provided in several ways depending upon local conditions. Hardpan may need to be broken up with dynamite. Tightly packed soils often are benefited by the introduction of compressed air beneath the planting floor. It may be necessary to provide several inches of gravel or crushed stone beneath the ball and very often a tile drainage system should be used. If tile is used it may be laid in a circular manner at the outside edge of holes dug for large trees in locations were considerable seepage into the tree pit can be anticipated or where the pit perhaps is twenty feet in diameter. A "V" or "Y" type of drain may be installed in larger holes but for those nine feet or less in diameter a single line of 3-inch tile covered with 2 inches or more of gravel or crushed stone should be adequate. Whatever type is provided, however, should be so placed that superfluous water does not stand beneath the tree but is drained away from the site. The so-called dry well is of no help unless it extends into a porous strata and in adobe soils frequently it is desirable to drill a hole with a post-hole digger or soil auger in the bottom of the tree pit until a porous strata is reached and fill the hole with crushed rock or gravel to facilitate drainage.

Preparation of Planting Bed.--If the existing soil is exceptionally poor a suitable bed of good soil may be provided beneath the ball. This may consist of a foot or more of sandy loam free from lumps, large stones, and sod. In recent years granulated peat moss has come into prominence as a soil conditioner and to improve aeration when well mixed with soil, and its use is highly recommended as mentioned previously. It is inadvisable to use manures (unless thoroughly composted), or other raw organic materials in the preparation of a planting

bed, especially in moist clay soils or where drainage is not of the best, since the gases generated in decomposition create unfavorable conditions for plant growth and the decomposition process robs the soil of necessary nitrogen. One large operator of established reputation goes one step further in preparing a planting bed for large trees. On top of a foot or two of well-mixed topsoil and peat moss he places a layer of clean sharp sand. (23) In any event if a special planting bed is prepared it should be thoroughly tamped and graded at a distance from the ground surface somewhat less than the depth of the ball to permit settling of the tree to its natural level. In average soils the preparation of a special planting bed is rarely necessary except for purposes of drainage since the presence of a bed of softer soil beneath a platformed tree makes it difficult to remove the platform.

The soil beneath the ball should be mounded slightly higher in the center of the hole so that when the tree is set much less force is needed to plumb or orient it properly. Trees are frequently dug from locations where the soil slope is different from that at the planting site, thus a mound in the center of the hole permits plumbing without throwing the tree off grade as much as might be done if the bottom of the entire tree pit were level. This practice also permits turning of platformed trees more readily and tends to prevent air pockets in the soil under the center of the ball.

Planting the Tree

The procedure followed in unloading a platformed tree, getting it into the hole, and removing the lacing, burlap, and platform is essentially the reverse of that described in balling and loading the tree. The tree is skidded off the truck and into the hole on planks and rollers. If the depth of the hole has been correctly calculated and the tree properly oriented, the platform, lacing, and burlap may then be removed.

If the ball and hole have been measured incorrectly, however, it will be necessary to raise or lower the tree to the proper depth before the platform and lacing are removed since it is important to have the tree remain, after settling, at the same depth that it grew previously. Raising the sides of the platform alternately will permit excavation or filling on one side at a time until the correct position is attained. At the same time the platform may be twisted around in the hole until the tree is oriented properly, although it is preferable to do any necessary orienting before the tree is lowered into the hole.

Usually it is desirable to release major tied-in branches prior to final orientation so that the shape of the tree can be observed. Many expert tree movers carefully orient the tree with reference to the compass direction in which it originally grew and where it is possible to follow this procedure--factors of shape, shade, etc., being favorable--it is recommended as

good standard practice, particularly for sugar maples. Since most trees, however, have one side that is better shaped or fuller than the others and since in most ornamental planting it is desirable to consider this point in placing the tree, the matter of compass orientation frequently must be disregarded.

After the tree is located in the desired position the rope mat is placed on the side of the ball toward the ramp, the ends hooked to a cable or rope which is anchored to a tree or deadman, and the platform snaked out from under the ball and up the ramp by means of the winch cable. Then the lacing and burlap are removed.

When especially large trees are moved by the platform method, root balls may be so heavy that pulling the platform from beneath them is very difficult or practically impossible. In such cases it may be more practical to pull the platformed tree to the bottom of the ramp; anchor the platform; and skid the tree off the platform and into the hole by means of the rope mat and winch cable. A layer of mud in the bottom of the tree pit will facilitate the skidding of a heavy tree ball from the platform.

FIG. 30
3-WAY GUYING

Guying.—Although trees should be planted plumb so that the only time guys are under tension is when resisting wind, it is a good plan to guy large trees at this stage. Several satisfactory methods of guying are in use, but for large trees with heavy tops the best system includes the use of lag hooks, 7-wire galvanized strand, turnbuckles, and some type of underground deadmen or anchors. (Fig. 30) Lag hooks screwed directly into the trunk probably injure the tree less in the long run than loops through crotches, even if protected by rubber hose guards. The 7-wire strand and turnbuckle arrangement is strong and readily permits adjustment, and the sunken anchors or deadmen are less liable to displacement than stakes. Three guys, spaced equally around the tree, are generally satisfactory, but especially large trees may require additional support. Guying is also discussed on pages 25 and 30.

The practice of using wooden braces in place of guy wires sometimes observed in the Middle West and Southwest, has little to recommend it. The writer has had occasion to examine a con-

siderable number of trees braced in this manner and a large percentage showed definite injury at the point of contact with the trunk. Then, too, the wooden braces are more conspicuous than wires or cables and hence detract from the appearance of the operation.

Backfilling.—In connection with the placing of backfill around the ball several things should be kept in mind. In order to induce rapid root growth the soil placed around the ball should be of good quality and friable in texture, moisture should be ample but not excessive, and excessive tamping of wet soil or "puddling" should be avoided. The use of granulated peat moss well mixed with a good grade of topsoil provides an ideal medium for rapid root growth, and its use is recommended whenever possible.

Although fertilizers frequently are used or recommended for use in connection with tree planting, many experienced plantsmen prefer to defer their use until after growth has started. Immediate applications appear to have less beneficial effect than delayed applications and in some instances—particularly with bare-rooted stock—have been actually harmful. The more important factors for inducing rapid root growth are plenty of moisture, good drainage, and a well ventilated soil. Fertilizing at the time of planting bare-rooted stock is not recommended as a Park Service practice, but balled stock may be fertilized if desired by mixing thoroughly a moderate quantity of a complete fertilizer high in phosphorus—perhaps 2 pounds per inch of trunk diameter—with the backfill.

About 6 inches of the peat and soil mixture is shoveled around the ball to begin the backfill. This is well tamped and a quantity of water poured in and allowed to drain away to settle the soil firmly around the root ball and fill any air pockets. Additional layers are added and tamped until the hole is completely filled except for a shallow saucer left around the tree for watering. The top 3 or 4 inches of the backfill should not be tamped but should be left loose as an earth mulch and no tamping should be done—even on large trees—after watering unless the soil is particularly light because of the danger of puddling and compacting the soil to a dangerous degree. Air pockets may be checked with a crowbar and filled with sand or fine soil.

Mulching.—In addition to keeping the top layer of the soil loosened, generally it is considered good practice to add a mulch of peat moss, well rotted manure, straw, hay, leaf mold, or some similar coarse organic material which will decrease evaporation of the soil moisture, tend to keep the soil from packing, keep the soil at warmer temperatures, and retard rapid soil temperature changes. The mulch may be from 2 to 6 inches in depth, depending upon the material used, and the soil surface beneath it should be loosened occasionally to keep it from packing. It should be understood that a mulch is not a substitute for cultivation. Probably no maintenance item is more im-

portant for the first year or two after transplanting than frequent cultivation to conserve soil moisture. Mulching is also discussed on pages 23 and 29.

Pruning.—The pruning of the top of a large transplanted tree usually is best deferred until it is planted, guyed, and any ties removed. This enables the pruner to judge the shape of the tree better and to remove or treat any branches accidentally broken in the operation.

Considerable judgment is necessary in pruning a large transplanted tree. (52) Since the permanent structural framework of the tree has been formed already, pruning should not destroy or mutilate this, but at the same time enough growth should be removed to compensate for root loss. As a general rule, from one-half to two-thirds of the buds of wilding deciduous stock should be removed but if the tree has an especially good fibrous root system and if planting conditions are extremely favorable and adequate maintenance is assured the amount of pruning may be reduced proportionately. In some cases the removal of broken branches or those which rub against or are too close to others may suffice, but some additional pruning, thinning, or defoliation usually is necessary. Pruning is also discussed on pages 23 and 30.

Wrapping.—The same reasons for wrapping small trees and the technique of application described on page 26 and illustrated in Figure 10, apply as well to large trees which need this protection even more than smaller ones.

Maintenance

The larger the tree, generally speaking, the more careful maintenance it must have until it is well established. This phase of transplanting has been described with some care earlier in this bulletin so there is no need to duplicate such description at this point. One who is relatively inexperienced in handling large trees would do well to become thoroughly familiar with the after-care necessary for transplanted stock mentioned herein and in the various references given in the bibliography.

* * *

TREE MOVING MACHINERY

Although the art of large tree moving has been known and practiced at least since the thirteenth century the machinery and equipment used in the early years was crude and cumbersome and the technique less refined than today. Few important mechanical improvements were made until the present century when the availability of the motor truck and an increased interest in large tree moving for immediate effects stimulated the development of specialized machinery capable of handling trees weighing many tons quickly, efficiently, and with a minimum of human labor. The modern tendency to move nearly all large trees with a substantial ball of earth around the roots has required the use of stronger and more efficient machines than those used formerly when most trees were moved bare-rooted.

Suitable equipment for moving large trees is frequently designed and constructed either by or under the direction of an individual operator, but there are now on the market several well-designed tree movers available to individuals or organizations. Each type and refinement of type has certain advantages and disadvantages of cost, strength, capacity, weight, adaptability, maneuverability, etc., and it is safe to say that no one type, make, or size may be used universally with maximum effectiveness. Each has its demonstrated value when used for the purpose and in the manner for which it was designed. Present-day tree movers may be classified into two major categories —the trailer and automotive.

Trailer Types

The trailer type of tree mover is usually a four-wheeled apparatus, the motive power for which formerly was supplied by horses, but which is now drawn by trucks or tractors. Varieties of the trailer type of mover may be made with six, eight, or

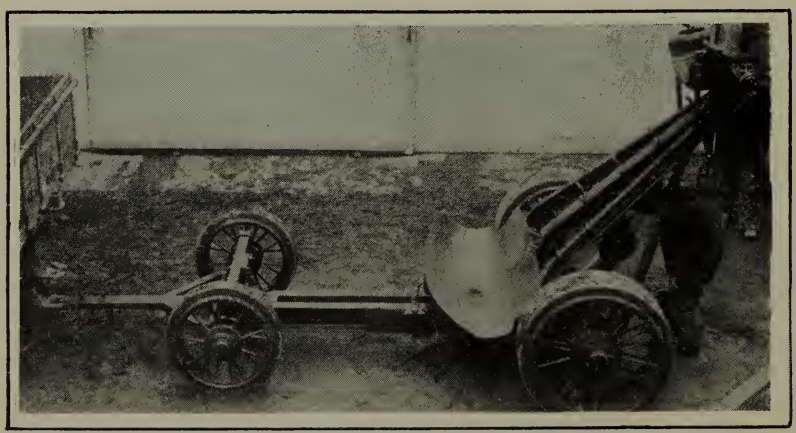


PHOTO COURTESY CHAS. F. IRISH CO.

FIG. 31. TYPE-A. TREE MOVING TRAILER

PHOTO COURTESY ROCK CREEK NURSERIES

FIG. 32. TYPE-B. TREE MOVING TRAILER

sometimes with only two wheels. Two major types are illustrated in Figures 31 and 32.

The majority of trailer movers are devised so that most of the weight of the tree and the ball is pivoted on and is carried by the rear wheels--the front wheels being of use principally to balance and guide the loaded mover. In most cases a framework of steel or timber beams is arranged across the rear axle so that the trunk is supported in a cradle at one end with the root ball at the other resting in a scoop or on a platform supported partially by the front wheels. (Fig. 31)

At least one type of mover depends entirely on holding the ball rigid enough as it is tipped to make any direct contact with the trunk unnecessary. (Fig. 32) When a tree is being moved with this mover, the tree ball is dug, burlapped, and laced with rope or baled with heavy wire fencing in the usual manner. The bottom of the ball is undercut for placing the lifting plate and shoes of the mover. Then the mover is placed in the hole against the ball and the shearing skids placed and tightened. The top split skids are placed on top of the ball and hooked to the mover and shearing skids thus clamping the ball to the mover. The tree is pulled over by means of an adjustable loading pole without leverage on the trunk. Then the balance of the mover unit is bolted in place and pulled out of the hole by means of tractor or a cable attached to a winch on a truck. In planting, a reverse process is followed.

Still a third type of mover, an illustration for which could not be obtained, supports the tree by means of a cradle placed at the junction of the trunk and roots and balances the load through bracing and a long lever pole.

Automotive Types

At least five distinct types of automotive tree movers have been developed in recent years. For purposes of discussion these have been arbitrarily classed as Types A, B, C, D, and E and are illustrated in Figures 33 to 37 inclusive.

Type A.—The simplest type of automotive tree mover consists of a simple A-frame mounted on an ordinary platform truck. (Fig. 33) Motive power to hoist the boom and load line may be supplied by hand or power winches or by ordinary block and tackle for light loads.

N. P. S. PHOTO

FIG. 33 TYPE-A. AUTOMOTIVE TREE MOVING MACHINE

Type B.—This mover is essentially an elaboration and refinement of Type A. It consists of a gooseneck crane mounted on a curved bed, double rear axle, 10-wheel truck and is especially designed for moving trees. (Fig. 34) Double- and single-drum power winches supply the motive power. The single-drum winch handles the load line which is fastened by chains or heavy ropes to the ball. One of the drums of the double-drum winch handles the tree line used to steady and balance the tree and the other hoists and lowers the boom. This type of mover has a capacity up to 9 tons.

In operation the tree is dug, burlapped, and laced in the usual manner. The load line is fastened to the ball which is broken loose from the ground. The tree line is fastened to the trunk about 15 to 20 feet above the roots, and the ball is hoisted close to the boom. Then the boom is raised to let the ball swing in and be lowered to the curved cradle. The boom is lowered until it rests on the ball, the tree line is pulled taut, and a sling fastened to the chassis from the truck. The reverse of this process is followed in unloading

PHOTO COURTESY GAR WOOD INDUSTRIES INC.

FIG. 34. TYPE-B. AUTOMOTIVE TREE MOVING MACHINE

Type C.—This type of tree mover consists of a steel superstructure mounted on a flat or arched bed truck. (Fig. 35) Four upright beams support a double overhead track with a trolley inside the track which is equipped with a swivel. Jacks mounted at the rear of the truck prevent the truck from overturning.

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FIG. 35. TYPE-C. AUTOMOTIVE TREE MOVING MACHINE

A larger size is equipped with a heavy winch and power take-off and is suitable for mounting on a standard truck of not less than 2½-ton capacity. It will handle trees with balls of earth up to 7 feet in diameter weighing up to 4 or 5 tons. The smaller machine may be equipped with either a hand or power winch and is suitable for use on a standard 1½-ton truck. It will handle trees with balls of earth up to 6 feet in diameter weighing from 2 to 3 tons.

The tree to be moved is dug with a smooth round ball and suitably burlapped. A hollow pin is driven through the ball at the lower end of which a steel plate is fastened. At the top of the pin an adjustable chain is fastened to a heavy rubber belt around the trunk. As the tree is lifted, the top is gradually lowered into a horizontal position. When the ball is raised to the truck it is secured to the trolley which is drawn in along the track and the tree is deposited on the curved truck bed. In unloading the process is reversed.

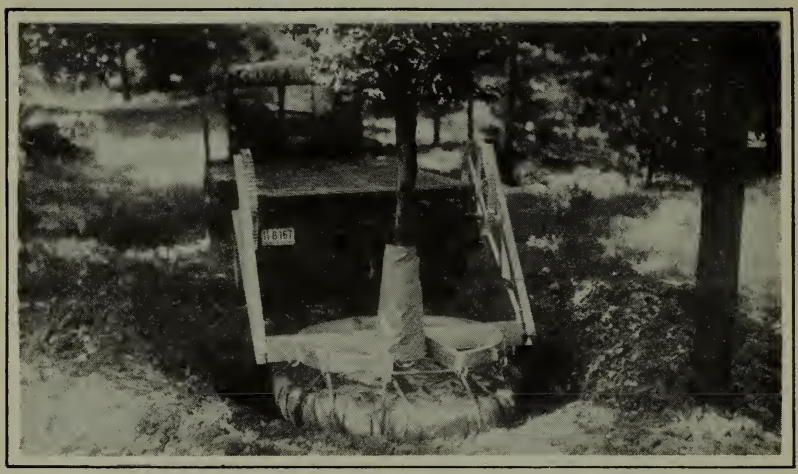

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FIG. 36. TYPE-D. AUTOMOTIVE TREE MOVING MACHINE

Type D.—The Type D automotive tree mover reduced to essentials consists of powered lever arms mounted on the sides and at the rear of a heavy capacity truck equipped with dual rear wheels. The two arms support a swiveled circular framework which is provided with a wide slot for receiving the trunk of the tree being moved. (Fig. 36) Motive power is through a power take-off geared winch mounted at the rear and beneath the chassis.

In use the truck is backed up to a tree previously dug, burlapped, and laced. The ball is attached with heavy rope to hooks provided around the circular framework. As the tree is lifted the latter ropes support the balled tree which is swung in an arc until the ball rests on the truck platform. The tree

may be carried upright, horizontal, or at any angle between. Balls up to 7½ feet in diameter and loads up to 6 tons may be carried on this type of mover.

Type E.—This type of tree mover consists of an adjustable boom, pivoted on rollers at the rear end of a heavy duty truck which is equipped with a power winch and a power take-off roller chain to control the boom. (Fig. 37)

PHOTO COURTESY J. G. BUTTS

FIG. 37. TYPE-E. AUTOMOTIVE TREE MOVING MACHINE

In use, the truck is backed up to the tree which has been dug previously with a suitably sized ball. The boom is raised against the tree to permit the trunk to rest in padded saddles at each end of the boom. The tree ball is supported by means of a steel rod through the ball which is pinned to a steel plate on the lower surface. The upper end of the rod is connected to the cable which secures the tree trunk to the upper saddle. When the boom is lowered it raises the tree out of the hole and places it in a horizontal position on top of the truck—crown forward—in which position it is carried until unloaded in a reverse process.

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